

**ECONOMIC IMPACT OF SUNFLOWER PRODUCTION
TECHNOLOGIES UNDER ALL INDIA CO-ORDINATED
RESEARCH PROJECT (AICRP) IN KARNATAKA**

PRAKASH K.N.

PALB-1101

**DEPARTMENT OF AGRICULTURAL ECONOMICS
UNIVERSITY OF AGRICULTURAL SCIENCES,
BANGALORE- 560 065**

2013

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TECHNOLOGIES UNDER ALL INDIA CO-ORDINATED
RESEARCH PROJECT (AICRP) IN KARNATAKA**

**PRAKASH K.N.
PALB-1101**

Thesis submitted to the

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Master of Science (Agriculture)

In

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***Affectionately
Dedicated
To***

My beloved family members

Mother - Radhamma

Father -Nanjundappa K.M.

Sister - prathiba K.N.

Uncle - Channappa S.M.

Aunty – Anusuya G.K.

Cousins - sarvesh sandesh

santhosh

**DEPARTMENT OF AGRICULTURAL ECONOMICS
UNIVERSITY OF AGRICULTURAL SCIENCES,
GKVK, BANGALORE**

CERTIFICATE

This is to certify that the thesis entitled “**Economic impact of Sunflower production technologies under All India Co-ordinated Research Project (AICRP) in Karnataka**” submitted by **Mr. PRAKASH K.N., ID No. PALB-1101**, for the degree of **Master Of Sciences (Agriculture) in Agricultural Economics** to the University of Agricultural Sciences, Bangalore, is a record of research work carried out by him during the period of his study in this university, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

BANGALORE
July, 2013

(B.V. Chinnappa Reddy)
Professor
Department of agricultural economics,
UAS, GKVK, Bengaluru-65

Approved by:

Chairman: _____
(B.V. Chinnappa Reddy)

Members: 1. _____
(K.B. Umesh)

2. _____
(M.N. Venkataramana)

3. _____
(S.C. Ramesh Kumar)

4. _____
(D.M. Gowda)

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PRAKASH K.N.

**Economic impact of sunflower production technologies under all
India co-ordinated research project (AICRP) in Karnataka**

PRAKASH K.N

ABSTRACT

The present study is designed with the overall objective of assessment of the economic impact and efficiency of sunflower technologies released by AICRP in the University of Agricultural Sciences, Bangalore. All India Coordinated Research Project (AICRP) on sunflower functioning since 1977 has made concerted efforts to address the regional problems by developing production technologies suitable for different states including Karnataka. During the period 1980-2010, the state had registered a positive significant growth of 6.15 percent in area and 5.61 percent in production. However, the productivity growth was non-significant with negative growth rate. Irrigated sunflower in Karnataka, during the period 1990-2010, registered a significant growth both in production (4.61%) and productivity (2.00%). However, the growth rate in area (2.52%) was positive but non-significant. The gross returns as well as net returns were highest in the case of Chikkaballapur at Rs 24600 and Rs 9541, respectively. The ratio of net return per rupee invested in sunflower among sample respondents was highest in Chikkaballapur (0.63) followed by Chikmagalur (0.57) and Chitradurga (0.48). The yield gap in sunflower was 3.40 qtl/ha between potential and average farmers yield in rainfed areas and 10.66 qtl/ha in irrigated condition in Karnataka state. The estimates of TFP for sunflower in the state varied from 1.13 in 1991-92 to 1.06 in 2010-11. The output growth was highest (2.30) in the year 2007-08. The highest (2.07) input growth was recorded in the year 1994-95. The IRR for research investment on AICRP centre Bangalore was estimated at 7.87 per cent, which shows that it is a reasonable return to research investment.

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UAS, GKVK, BANGALORE

B.V. Chinnappareddy

(Major advisor)

ಕರ್ನಾಟಕದಲ್ಲಿನ ಅಖಿಲ ಭಾರತ ಸುಸಂಘಟಿತ ಸಂಶೋಧನಾ ಯೋಜನೆಯ ಅಡಿಯಲ್ಲಿ ಸೂರ್ಯಕಾಂತಿ

ಉತ್ಪಾದನಾ ತಂತ್ರಜ್ಞಾನಗಳ ಆರ್ಥಿಕ ಪರಿಣಾಮ

ಪ್ರಕಾಶ ಕೆ. ಎನ್

ಸಾರಾಂಶ

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವನ್ನು ಸೂರ್ಯಕಾಂತಿ ಅಖಿಲ ಭಾರತ ಸುಸಂಘಟಿತ ಸಂಶೋಧನಾ ಯೋಜನೆ (AICRP) 1977 ರಿಂದ ಬಿಡುಗಡೆ ಮಾಡಿದ್ದ ಸೂರ್ಯಕಾಂತಿ ತಂತ್ರಜ್ಞಾನಗಳ ಆರ್ಥಿಕ ಪ್ರಭಾವ ಮತ್ತು ದಕ್ಷತೆಯ ಮೌಲ್ಯಮಾಪನಕ್ಕಾಗಿ ಬೆಂಗಳೂರು ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾನಿಲಯದಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಗಿತ್ತು. ಸೂರ್ಯಕಾಂತಿ ಕಾರ್ಯನಿರ್ವಹಣೆಯ ಮೇಲೆ ಕರ್ನಾಟಕ ಸೇರಿದಂತೆ ವಿವಿಧ ರಾಜ್ಯಗಳ ಸೂಕ್ತವಾದ ಉತ್ಪಾದನಾ ತಂತ್ರಜ್ಞಾನಗಳು ಅಭಿವೃದ್ಧಿ ಮೂಲಕ ಪ್ರಾದೇಶಿಕ ಸಮಸ್ಯೆಗಳನ್ನು ಬಗೆಹರಿಸಲು ಗೋಷ್ಠಿ ಪ್ರಯತ್ನಿಸಿತು. 1980-2010 ಅವಧಿಯಲ್ಲಿ, ರಾಜ್ಯದ ಉತ್ಪಾದನೆಯಲ್ಲಿ ಧನಾತ್ಮಕ ಗಮನಾರ್ಹ, ಪ್ರದೇಶದಲ್ಲಿ 6.15 ಪ್ರತಿಶತ ಬೆಳವಣಿಗೆ ಮತ್ತು 5.61 ಶೇಕಡಾ ದಾಖಲಾಗಿದೆ. ಆದರೆ, ಉತ್ಪಾದನಾ ಬೆಳವಣಿಗೆ ಋಣಾತ್ಮಕ ಬೆಳವಣಿಗೆ ದರವು ಗಮನಾರ್ಹವಾಗಿಲ್ಲ. 1990-2010ರ ಅವಧಿಯಲ್ಲಿ ಕರ್ನಾಟಕದ ನೀರಾವರಿ ಸೂರ್ಯಕಾಂತಿಯ, ಬೆಳವಣಿಗೆ (4.61%) ಹಾಗೂ ಉತ್ಪಾದನೆಯು (2.00%) ಗಮನಾರ್ಹವಾಗಿ ಹೆಚ್ಚಿರುವುದು ಕಂಡುಬಂದಿದೆ ಆದಾಗ್ಯೂ, ಬೆಳವಣಿಗೆ ಪ್ರದೇಶದಲ್ಲಿ ದರ (2.52%) ಸಕಾರಾತ್ಮಕವಾಗಿದ್ದು ಇದು ಗಮನಾರ್ಹವಾಗಿಲ್ಲ. ಅಧ್ಯಯನದ ಫಲಿತಾಂಶದ ಒಟ್ಟು ಆದಾಯ ಹಾಗೂ ನಿವ್ವಳ ಆದಾಯವು ಕ್ರಮವಾಗಿ ರೂ 24600 ಮತ್ತು ರೂ 9541 ಚಿಕ್ಕಬಳ್ಳಾಪುರ ಪ್ರದೇಶದಲ್ಲಿ ಅತ್ಯಧಿಕವಾಗಿದೆ. ಮಾದರಿ ಪ್ರತಿಕ್ರಿಯೆ ನಡುವೆ ಸೂರ್ಯಕಾಂತಿ ಬಂಡವಾಳ ಪ್ರತಿ ರೂಪಾಯಿಗೆ ನಿವ್ವಳ ಲಾಭ ಅನುಪಾತವು ಕ್ರಮವಾಗಿ ಚಿಕ್ಕಮಗಳೂರು (0.57), ಚಿತ್ರದುರ್ಗ (0.48) ನಂತರ ಚಿಕ್ಕಬಳ್ಳಾಪುರದಲ್ಲಿ (0.63) ಅತಿ ಹೆಚ್ಚು ಕಂಡುಬಂದಿದೆ. ಕರ್ನಾಟಕ ರಾಜ್ಯದ ನೀರಾವರಿ ಸ್ಥಿತಿಯಲ್ಲಿ ಸೂರ್ಯಕಾಂತಿ ಇಳುವರಿ ಅಂತರವು ಪ್ರತಿ ಹೆಕ್ಟೇರಿಗೆ 10.66 ಕ್ವಿಂಟಲ್ ಮತ್ತು ಸಾಮರ್ಥ್ಯ ಮತ್ತು ಸರಾಸರಿ ರೈತರು ಮಳೆ ಆಶ್ರಯ ಪ್ರದೇಶಗಳಲ್ಲಿ ಇಳುವರಿ ಅಂತರವು ಪ್ರತಿ ಹೆಕ್ಟೇರಿಗೆ 3.40 ಕ್ವಿಂಟಲ್ ದಾಖಲಾಗಿದೆ. ರಾಜ್ಯದಲ್ಲಿ 1991-92 2010-11 ರಲ್ಲಿ ಸೂರ್ಯಕಾಂತಿ TFP ಅಂದಾಜು 1.13 ರಿಂದ 1.06 ಬದಲಾಗುತ್ತಿದ್ದವು. ಉತ್ಪಾದನೆ ಬೆಳವಣಿಗೆ ವರ್ಷ 2007-08 ರಲ್ಲಿ (2.30) ಹೆಚ್ಚಿನದಾಗಿದೆ. ಅತ್ಯಧಿಕ (2.07) ಇನ್ಪುಟ್ ಬೆಳವಣಿಗೆ ವರ್ಷ 1994-95 ರಲ್ಲಿ ದಾಖಲಾಗಿದೆ. AICRP ಸೆಂಟರ್ ಬೆಂಗಳೂರು ಮೇಲೆ ಸಂಶೋಧನೆ ಹೂಡಿಕೆಗೆ IRR ಶೇಕಡಾ 7.87 ಎಂದು ಅಂದಾಜಿಸಲಾಗಿದೆ.

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(ಪ್ರಧಾನ ಸಲಹೆಗಾರರು)

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INTRODUCTION

I INTRODUCTION

Resources are scarce worldwide therefore, all governments and foreign aid donors, need to justify their investments empirically in public welfare programmes. In view of scarcity of resources the economic value of public investments may not be obvious. However, due to various reasons, it is particularly difficult to observe the impact of agricultural research, because benefits are spread over many years and across millions of dispersed producers and consumers. Hence, economic studies are needed to measure the impact focusing benefits and compare them with the costs of the research. With appropriate evaluation of research impacts, scientists can target their mandates to achieve the greatest possible payoffs. Besides, documentation of research impacts is also needed to bargain and ensure appropriate level of public support and to meet the expectations of the public. Without clear and persuasive demonstrations of its benefits, research is unlikely to attract the sustained funding.

Improvement in technology, driven by application of scientific research to practical problems is the core of economic growth and development. However, the economic value of public investment in research may not be apparent easily. Hence, it is difficult to observe particularly the impact of agricultural research. Agricultural R&D have a real cost to the society because of forgone alternatives. The economic aspect of the project evaluation expects that the project contributes significantly to the development of the total economy and that its contribution is great enough to justify the resources devoted. Therefore, economic studies are needed to show and determine flow of benefits, in order to compare them with cost of research and extension. Such an evaluation could determine whether investment earns a rate of return which exceeds the interest rate or cost of borrowed funds (opportunity cost). This assumes a greater significance in view of increased borrowed investment for R&D in agriculture in the country.

The role of the State in augmenting agricultural productivity is crucial as private investment in agricultural research is very low and access to it by poor peasants is minimal. Technological innovations in agriculture, commonly known as 'The Green Revolution', gave further impetus to the enquiry into the role of investment, particularly of public investment in raising agricultural productivity. The goal of self-sufficiency was achieved through a great deal of investment on agricultural research and human resource development which led to the development of high yielding varieties and improved technologies both by public and private sectors. In addition, as supporting role to the agricultural technology, infrastructure needed for agricultural development such as irrigation, markets, credit, power, farm machinery & equipment etc was created through the state as well as private initiatives to enable farmers adopt new agricultural technologies.

One of the modes of achieving self sufficiency in food production in India has been the initiatives in agricultural research in the form of All India Coordinated Research Projects (AICRP) for important crops. As per this mandate the Directorate of Oilseeds Research (DOR) formerly operating as All India Coordinated Research Project on Oilseeds (AICORPO) came into existence on August 1, 1977 with the headquarters at Rajendranagar, Hyderabad. The AICRP on sunflower functioning since 1977 has made concerted efforts to address the regional problems by developing production technologies suitable for different states including Karnataka, which has a sizeable area under sunflower.

Sunflower is an important oil seed crop in Karnataka state. It occupies an area of 794 thousand hectares (indiastat.com) in 2009-10 which is 53.77 percent of total area under sunflower in the country. The aggregate production of sunflower in the state is about 304 thousand tons, which forms 35.73 percent of aggregate production of the country. Nutritionally sunflower is an important oil seed crop as it

has a high level of unsaturated fatty acids. The AICRP in the state has developed a number of sunflower hybrids and production technologies suitable to the state. This has enabled the state to occupy prime place in the production of sunflower oil seed in the country.

The AICRP centre at UAS Bangalore is one of the pioneering research centres on sunflower and it has a credit of developing country's first hybrid sunflower BSH-1. It has also developed several varieties, hybrids, production technologies and relevant package of practices for the cultivation of sunflower in the state. The technologies developed and recommended have been conveyed to farmers through the frontline demonstration on the farmers' fields and through extension services from the state departments. Quality seeds are supplied through various government and private agencies. The State Department of Agriculture and Seed Corporation are active in this regard. As a result of these efforts, large scale adoption of sunflower technologies has significantly enhanced the production and yields of sunflower in the state.

Taking the cue from Schultz, Hayami and Ruttan (1971) argued that a continuous stream of new technical knowledge and flow of institutional inputs in which the new knowledge is embodied represent a necessary condition for modern agricultural development. According to them, this stream of new technical inputs must be complemented by investments in general education and in production education for farmers. They also considered an effective system of public research institutions, private agricultural supply firms and markets for factors and products as the critical elements of the growth process.

In our country, a strong case for public investment in agriculture was made by Chakravorthy (1993). According to him, the role of the State as an investor is envisaged neither in the simple

Ricardian Model nor in the Marxian schemes of expanded reproduction. In India, the compulsions arising from the existing climatic and demographic characteristics require different types of investment including irrigation, fertilizers, better seeds, etc., and some of these capital inputs often require to be organized on a very large scale, which makes State intervention essential. Along with yield-increasing investments, there is also a need for investment in infrastructure such as transport and electricity to enlarge the market and to provide suitable energy base for sustainable growth. Moreover, the inducement to invest on the part of private investors is significantly affected by the behaviour of public investment. Therefore, Chakravarthy (1993) argued that transforming traditional agriculture means growing public investment involving a suitable mix of directly productive capital and social-overhead facilities.

A consensus that emerges from past studies is the necessity for public investment as a means to transform traditional agriculture and to raise agricultural productivity, though for different reasons. These reasons extend from the 'market failure' in providing certain important categories of investment due to externalities, to the complementarity of private investment with public investment. Education of the farmers, research and development, transport, marketing facilities and electrification, to mention only a few, are indispensable items of investment to enhance productivity and require direct governmental intervention (Shiyani, 2007).

Writing in 1964, Schultz noted that 'transforming traditional agriculture' warrants investment in physical and human capital. Productivity enhancement is the key to break vicious cycle of low production and poverty, the crucial feature of which is the low rate of return to investment that farmers have been making for generations. Significant opportunities for productivity growth in agriculture become available only through changes in technology – crop husbandry techniques, better seed varieties, more efficient sources of power and

cheaper plant nutrients. Investment in such activities as agricultural research leading to the supply of new input, and in the education of the farmers who are to use them, provides the basis for technical change and productivity growth in agriculture. Investment in these sectors, Schultz observes, is a matter of social goal and the existence of spill-over effects necessitates public investments in most of them, especially in research and development and education. Substantial amount of public funds have gone into the research and extension activities relating to the sunflower production. The government and the society are concerned with the contribution of agricultural research in sunflower to the nation or to the society in terms of increased productivity and returns from the research investment. Has the research investment contributed to the economic improvement of farmers? What is the overall contribution of research investment on sunflower? Questions such as these are often raised at various forums not only from policy point of view but also from view point of justification of research investment. To answer such questions, in-depth studies and evaluation of the economic impact of agricultural research are needed.

The present study attempts to assess the economic impact of sunflower technologies released by AICRP at the University of Agricultural Sciences, Bangalore. Studies of this type could be useful to demonstrate importance of research investment from the policy point of view. Further, the results of the study could also be an input for the design of programs of the University and the State to evolve research strategies towards sustainable food and livelihood security.

Significance of the study: A great deal of investment has gone into the development of sunflower based technologies in the state as well as at all India level. It is essential to understand from the policy point of view the effect of new technologies on the productivity of the crop and its impact on the economic conditions of the growers. Further, it is imperative to analyse the extent of adoption of sunflower

technologies and receive their feedback for further research endeavours in sunflower. Presently research budget for agriculture is shrinking over the years in real terms. Therefore, assessment of impact of new farm technologies and returns to research investment assume greater policy input in the era of shrinking research budgets in real terms. The available research studies on economic impact and returns to research have mainly focussed macro level perspectives. Keeping these issues in view the present study will focus more on micro level impacts.

The specific objectives of the study are:

1. To estimate productivity improvement of sunflower due to hybrid technology under AICRP.
2. To assess economic impact of AICRP technologies in sunflower.
3. To quantify TFP of hybrid technologies of sunflower.
4. To assess the returns to research investment on sunflower.
5. To analyze backward linkage to support sustenance of technologies transferred to farmers.

Hypothesis of the study

1. Substantial yield improvement has been observed in sunflower due to hybrid varieties.
2. Sunflower hybrids are more profitable than the high yielding varieties.
3. There was positive contribution of sunflower technology (TFP) to the sunflower production in Karnataka.
4. Returns to research investment are positive and higher.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

A review of past research studies helps in identifying the conceptual and methodological issues relevant to the study. This would enable the researcher to collect information and subject them to sound reasoning and meaningful interpretation. A brief review of the earlier research work related to the present study is presented in this chapter. Keeping in view the objectives of the present investigation, the reviews are presented in the following heads:

- 2.1 Productivity growth and growth rates in area and production,
- 2.2 Cost, returns, and economic impact of technologies,
- 2.3 Studies on total factor productivity,
- 2.4 Studies related returns to research investment in agriculture,

2.1 Productivity growth and growth rates in area and production

Evenson and Mckinsey (1991) undertook an empirical decomposition analysis that relates productivity growth to variables measuring technology and infrastructure. There was consistency between the partial factor productivity and total factor productivity results for public research and HYVs. The results for both public extension and private research tended to be higher in the TFP accounting. The infrastructure variables accounted for relatively little growth. The contribution of the public research system has been of major importance. The HYV computations indicated that varietal improvements contributed about one-fifth of partial factor production (PFP) growth and one third of TFP growth over the period. Non-varietal public research contributed roughly one third of PFP growth and one fifth of TFP growth. Together, they accounted for more than half of both PFP and TFP growth. Extension contributed roughly one

third of PFP growth. Private research appeared to have contributed significantly to TFP growth.

Coxhead (1992) indicated that in developing countries, growth rates of agricultural technology exhibits wide variations across environments because of heterogeneity of land quality. Technical change analysis employing aggregate data typically captures this information very imperfectly because observation units rarely coincide with area of environmental uniformity. The author presented a model permitting environment specific variation in the rate and factor bias of technical change when information on environmental qualities is limited. An application using the Philippine data reveals substantial discrepancies between irrigated and non-irrigated areas in the rate on the basis of technical change.

Huffman and Evenson (1992) indicated that although considerable variations existed in agricultural productivity across US states and sectors, a relatively small set of variables could be used to decompose or explain these differences. Some unusual differences in contributions of public agricultural research to productivity have been uncovered. Further, private sector research, public extension and farmers' schooling play an important role in the productivity.

Umesh *et al.* (1992) reported a marginal increase in the growth pattern of groundnut productivity and area which lead to a 1.81 per cent increase in production in Karnataka after green revolution, while a negative growth rate was noticed during the pre-green revolution period.

Bhowmick and Ahmed (1993) documented the growth rate in area, production and productivity of major oilseed crops in Assam during the pre and post-green revolution periods. Linear trends and compound growth rate of area, production and yield of oilseed crops were worked out by fitting linear function of the type $y = a + bt$ and exponential function of the type $y = ab^t$ during the period 1950-51 to

1980-81. The results indicated that increase in oilseeds production was related to increased acreage rather than intensification of production.

Choudhary *et al.* (1993) observed that India as a major oilseed producer has the largest area and production of three oilseed crops, namely groundnut, castor and sesamum. The paper estimated growth rate of area, production and yield of oilseeds and investigated the factors affecting the instability in yields of oilseed crops. The compound growth rate equation and trend equations were used for estimating variability in area, production and yield.

Singh *et al.* (1993) studied the growth trend of area, production and productivity of cotton in India. They found that cotton area in India increased by about 49 per cent during the last four decades. Similarly, production increased by 315 per cent in the year 1989-90, indicating that the increase in the cotton production was more on account of increased productivity rather than increase in cotton acreage alone.

Patil (1995) examined the growth in area, production and productivity of groundnut in Dharwad district and at the state level for the period 1984-85 to 1993-94 and found that the growth rate in area (0.51%) was positive but not significant as compared to the significant growth rate in production (6.89%) and productivity (6.34%) in Dharwad district. The growth rates in area (5.24%), production (10.00%) and productivity (4.63%) of ground nut during the same period for the state as whole were positive and significant.

Vani and Vyasulu (1996) studied the growth rates for three important cereals crops in Karnataka, namely rice, jowar and ragi in the three sub- periods 1955-56 to 1964-65, 1965-66 to 1979-80 and 1980-81 to 1989-90. The results indicated that in case of rice there was a positive growth rate in production and yield over the entire period and a negative growth rate in area. In the case of ragi, the

growth rate of production was higher than that of rice. A positive growth rate in area and production over the entire period with the highest growth in the second sub period was reported. In the case of jowar, there was a higher growth rate in area and production in most of the districts. Productivity in most of the districts was higher in the second period than in the first and third sub periods.

Pervez (2001) analyzed the growth in area, production and yield of major crops of Pakistan for a period 1970-71 (period I) to 1984-85 (period II). The study revealed that the increase in crop production was contributed largely by area than by productivity in Punjab and Sindh during period I. Sindh region recorded a higher growth in area, production and yield as compared to Punjab in period II. It was also observed that Punjab recorded a low degree of instability in growth rates in most of the crops as compared to Sindh region in period II.

Addisu *et al.* (2002) studied the growth performance of groundnut (area, production and productivity) in major groundnut growing districts of Karnataka for two periods from 1966 to 1980 and 1981 to 1997. Results revealed that the growth performance of area and productivity was not encouraging at state level during the study period. However, non-traditional groundnut growing districts like Tumkur, Kolar and Chitradurga registered significant growth both in area and production, where as productivity performance was almost stagnant in all the districts barring Dharwad, Kolar and Belgaum.

Lakhana (2003) studied the growth rates of area, production and productivity of groundnut in Gujarat for pre-technology mission on oilseeds (1970-71 to 1985-86) post- technology mission on oilseeds (1986-87 to 2001-02) and for over all period (1970-71 to 2002-02) for selected markets of Rajkot, Junagadh, Kalawad and Amrelin. The post- technology mission on oilseeds period had witnessed positive growth rates in area, yield and production. Growth of all the variables were found to be positive in over all period, however they were not

significant. Growth rates of area for Junagadh and Rajkot districts as well as for the state of Gujarat as a whole were positive and significant. However, growth rates of yield were negative throughout the study area during pre- technology mission on oilseeds. During post- technology mission on oilseeds growth rates of all variables were positive.

Singh and Srivastava (2003) studied the growth and instability in sugarcane area, production and productivity in Uttar Pradesh for different regions for the period from 1980-81 to 1998-99. Semi-log equations were fitted to estimate compound growth rates and coefficient of variation analysis to study the instability. Area, production and productivity under sugarcane registered a significant and positive growth rate in all the study regions and state as a whole. The variability coefficient was relatively higher in the central region but, western and eastern regions registered the lowest variability.

Varghese (2004) worked out the trend in area, production and productivity of cardamom in Kerala for a period from 1970-71 to 2002-03 using semi-logarithmic growth equation. The area under cardamom registered a negative growth rate (-1.216%) which was significant. The output showed an average annual growth rate of 4.14 per cent and yield registered an average annual growth rate of 5.51 per cent.

A study by Lathika and Kumar (2005) analysed growth trends in area, production and productivity of coconut for different coconut producing states/union territories in India. The period was divided into two sub-periods as phase I (1951 to 1995) and phase II (1996 to 2002). Area showed positive growth in both phases for selected states except for the Andaman and Nicobar islands where the growth was negative (-9.69) in II phase. Production also showed a positive growth in all the states in both the phases and Andhra Pradesh had highest growth in II phase (16.69%). The growth rate of productivity showed

negative growth in Kerala and Orissa in the I phase and Karnataka in the II phase.

Balcombe and Rapsomanikis (2010) empirically examined the impact of R&D on productivity, with special emphasis on lag selection. The results indicated that R&D expenditures had little or no influence on productivity growth rates beyond twenty years. Sometimes the impact of research on productivity may not have a long gestation period but may have an immediate impact, which may fade away after two or three years, and then have a positive impact some ten or more years later. Evidence of the existence of structural breaks was inconclusive. Future research was recommended to unearth the dynamic impact of a number of factors that determine productivity, the use of mechanical and chemical patents, which reflect R&D activities of the private sector, as explanatory variables, and the impact of such explanatory variables analyzed through more complex approaches that deal with count data or survival data.

2.2 Cost, returns, and economic impact of technologies

Olekar (1996) studied the comparative profitability of sunflower based cropping sequences under rainfed conditions in Bijapur district of Karnataka. In the case of small farmers, the net profit was highest in groundnut-sunflower cropping sequence (Rs.15356/ha) and least was in sunflower-fallow sequence (Rs.6685/ha). In the case of large farmers net returns were highest in groundnut-sunflower system. The benefit cost ratio was highest in the case of sunflower-chickpea sequence (2.51:1).

Kerur *et al.* (1997) while studying the economics of sunflower production in north Karnataka observed that per hectare cost of production of sunflower was Rs.5,652.55, Rs.5,693.11 and Rs.5,587.77 for small, medium and large farmers, respectively. The average yield obtained for the overall sample was 8.99 quintal per

hectare. The benefit cost ratio was 1.88 indicating sunflower production as a profitable enterprise.

Rahman (1999) in their study on “Impact of Technological Change on Income Distribution and Poverty in Bangladesh Agriculture” revealed that there were significant differences in production, productivity, variable costs, gross revenues and net incomes from groundnut between farmers who grew improved varieties and those who grew local varieties. Results indicated that adopters achieved better yields (724kg/ha) compared to non-adopters (567kg/ha). While the cost of production did not differ significantly between the two groups of farmers, adopters of improved varieties obtained better profits (MK 31429) than non adopters (MK 21957) due to the higher productivity. Improved groundnut growers had about 30% more production and productivity compared to the non-adopters. As farmers adopted improved varieties, there was a reduction in variable costs by about 15% suggesting that adopters of improved varieties benefit from doing so by reducing costs of the production (though this is not statistically significant). The cost of production may reduce for a number of reasons, but in the case of this study it is partly attributed to the fact that improved varieties are early maturing and thus potentially reduce labor costs. As a consequence adopters had substantially higher net incomes accruing from groundnut production than non-adopters.

De janvry *et al.* (2001) studied World Poverty and the Role of Agricultural Technology and their direct and indirect effects in Africa, Asia, and Latin America using SAM and CGE models and noticed that 10% increase in total factor productivity due to technological change such as improved seeds in all crops creates income gains for both urban and rural households. Overall the rural poor households enjoy an increase of 7.6% in their real income, mostly from direct effects and the urban poor an increase of 4.3%, from indirect income generation effects.

Alwang *et al.* (2003) in their study “Measuring the Impacts of Agricultural Research on Poverty Reduction in African Continent” observed that higher yields were found among adopters (1200 kg/ha versus 500 kg/ha for non-adopters) and incomes increased by 134% and cost reduced by 24%. The wives of adopters had access to more income, first from the household head who sold more grain and fodder and then from their own processing of the improved grains. Apart from investing supplemented incomes in food security and human capital (the education of children and health care), women also made savings and subsequently used them for investment in petty trading, or in the purchase of other assets, such as livestock.

McKinsey and Evenson (2003) analysed the impact of crop genetic improvement on Indian agriculture and observed that the productivity impacts of state research, private research, extension, and market development were positive. Extension and market development would not have made large impacts in the absence of modern varieties. Extension is productive when the extension service has new technology to extend. Similarly, the improvement of markets is important as it facilitates adoption and diffusion of modern varieties.

Cabanilla (2004) had estimated the potential impact of Bt maize on farms in the Philippines using a mixed integer programming procedure. Based on representative technologies and farms he found that farms with bt maize had 25% higher yield than other varieties.

Yorobe and Quicoy (2004) analysed the Economic Impact of Bt corn in the Philippines and estimated the partial productivity impact of Bt maize in the Philippines with sample data from 470 farmers in four provinces of the country, for a single cropping season. They controlled agro climatic factors by selecting adjacent adopters and non-adopters, correcting for sample selection bias through application of a two-stage, Heckman procedure. Yield and income were higher among Bt growers

and insecticide expenditure was lower. The converse was also true income, as well as education, significantly influenced the adoption of Bt maize.

Qaim and de Janvry's (2005) analysis of HT soybeans in Argentina is one of the most complete single articles in terms of hypotheses tested and methods applied. The authors build a series of econometric models to estimate the farm level impacts of HT soybeans on pesticide use, yields, efficiency and equity. They developed a biological model to portray the durability of the benefits. They concluded that BT use is associated with lower rates of pesticide use and that since Argentine farmers use lower levels relative to some countries, yield gains are relatively higher and reduced the cost of production.

Hossain (2006) studied the adoption and productivity impact of modern rice varieties in Bangladesh using household-level data from sample surveys to estimate the effect of the adoption of different generations of MV on farm incomes and productive efficiency. The residual payments in the cultivation of MV over that of TV measure the net return to the farmer from the adoption of MV, as the increase in cost associated with the adoption of MV has been deducted from the increase in gross revenue. The net return from the adoption was US\$93 for the wet season and US\$174 for the dry season in 1987. The return had increased substantially to US\$136 and US\$270, respectively, for the wet and dry seasons in 2000.

2.3 Studies on total factor productivity

Dey and Evenson (1991) studied the economic impact of rice research in Bangladesh and estimated the TFP growth for rice at 0.98 per cent per year for the period 1951- 71 and a little higher (1.15 per cent) during 1973-89, the era of use of HYVs. The contribution of TFP to agricultural output growth was 40-60 per cent, which was quite high. For wheat crop, TFP growth rate was estimated at 0.93 per cent per year

during the period 1952-71 and 0.83 per cent during 1973-89. It has contributed only 11 - 19 per cent in the growth of wheat production. For the crop sector, TFP growth rate was 0.72 per cent during the period 1952-71, which slightly improved with the adoption of HYVs and improvement in irrigation infrastructure.

Kumar and Rosegrant (1994) estimated TFP growth for rice. They found that the TFP index had risen by around 1.85 per cent annually in the southern region, 0.76 per cent in the northern and 0.36 per cent in the eastern region. In the western region, due to wide fluctuations in weather wide variation in the TFP index was observed and the estimated annual growth was negative (-0.98), but insignificant.

Fan *et al.* (1998) estimated TFP for agriculture at state-level using Tornqvist-Theil index for the period 1970-1994. The study finds that total factor productivity for India grew at an average annual rate of 0.69 percent between 1970 and 1995. In the 1970s, total factor productivity improved rapidly, growing at 1.44 percent per annum. The growth was faster in the 1980s at 1.99 percent per annum. But since 1990, total factor productivity growth in Indian agriculture has declined by 0.59 percent per annum. The study also reported state-level estimates- for the whole period 1970 to 1994. The states with TFP growth rate in the range 0-1 percent per annum were Andhra Pradesh, Karnataka, Uttar Pradesh, Himachal Pradesh and Kerala. The TFP growth was greater than 1 percent in Punjab, Bihar, Orissa, Maharashtra, West Bengal and J&K. The states with negative TFP growth are Haryana, Madhya Pradesh, Gujarat, Assam and Rajasthan.

Evenson *et al.* (1999) conducted a study on agricultural research and productivity growth in India. To estimate total factor productivity, the researchers used Tornqvist- Theil TFP index. Data were collected for the period 1956/57 to 1987/88 in 271 districts covering 13 states. The study revealed that India has made significant gains in TFP. The high-yielding varieties of wheat and rice introduced in the late 1960s

certainly contributed to these gains. Growth in TFP has contributed 1.1–1.3 per cent per year to crop production growth in India. Conventional inputs have contributed about 1.1 per cent per year since 1956. TFP and conventional inputs had contributed roughly 2.3 per cent per year to the growth of crop production.

Murgai (1999) uses Tornqvist-Theil Index to estimate TFP growth in Punjab at district level during 1960-1993. TFP growth averaged 1.9 percent from 1960 to 1993. Productivity growth in Punjab was lowest during the green revolution years, even as farmers moved from traditional varieties of wheat and rice to modern hybrid seed varieties and the agricultural sector experienced high growth rates in production. The study attributes most yield improvements to rapid factor accumulation, particularly that of fertilizers and capital. Contrary to widespread belief, the contribution of productivity growth to economic growth was small.

Forstner *et al.* (2001) computed Malmquist TFP index using Data Envelopment Analysis to estimate productivity change over about two decades for 32 Least Developed Countries. They found an overall decline in total factor productivity (TFP), pointing to technology as a major problem area in the growth of these countries. The study, however acknowledges that behind such decline, there seems to be 'best-practice regress'.

Mukherjee and Kuroda (2001) used Törnqvist-Theil methodology to construct the TFP index for Indian agriculture in fourteen states from 1973 to 1993. They found TFP index to be 1.73 for 1973-79, 2.51 for 1980-89, 1.34 for 1990-1993 and 2.19 for entire period 1973-2003. Bosworth and Collins (2007) used growth accounting approach and estimated TFP growth in primary sector for India as 0.8% during 1978-2004, 1% for the period 1978-1993 and 0.5% for the period 1993-2004.

Nin *et al.* (2003) estimated TFP growth for 20 countries during 1961-1994 using non parametric Malmquist TFP index with an alternative definition of technology- sequential technology and found that the earlier results reversed most of the developing countries experience productivity growth.

Bhushan (2005) used Data Envelopment Analysis to estimate Malmquist TFP index for major wheat producing states in India- Punjab, Haryana, Madhya Pradesh, Uttar Pradesh and Rajasthan. He finds TFP growth rate to be highest in Punjab and Haryana which is attributed to technical progress in these two states. Rajasthan (with no efficiency change) and Uttar Pradesh (with improvement in efficiency and negative growth in technological progress) had positive TFP growth rate while Madhya Pradesh (no change in efficiency and negative growth of technical progress) is reported to have recorded negative TFP growth rate. As compared to 1980s, mean growth of TFP was higher in 1990s and the primary source of TFP growth was technical progress and not efficiency improvements.

Kumar and Mittal (2006) estimated crop-specific TFP growth across different states for paddy and wheat. They found that TFP of paddy had started showing deceleration in Haryana and Punjab but TFP of wheat was still growing in these two Green Revolution states. About 60 per cent of the area under coarse cereals was facing stagnated TFP. Similarly, the productivity gains which occurred for pulses and sugarcane during the early years of Green Revolution, have now exhausted their potential.

2.4 Studies related Returns to Research Investment in agriculture

Araji *et al.* (1978) analysed the expected returns to investment in current research and extension programmes for nine agricultural commodities in the western region of India. The results indicated that the internal rate of return to public investment in combined research and extension programmes of agriculture ranged from 33 per cent for

sheep to 104 per cent for potatoes. The authors pointed out that depending on the commodity and nature of the research programme, 25 to 60 per cent of the expected returns to public investment in agricultural research will not be realised without extension involvement.

Evenson and Jha (1973) had estimated the productivity of agricultural research in India. They adopted total factor productivity approach to capture the returns to investment in agricultural research and extension. Since productivity gains in Indian agriculture are mainly generated by the research system, authors estimated the productivity growth as a residual, i.e., the difference between the growth rate in output and growth rate in inputs. Further, it is hypothesized that research benefit accrued is not only due to state research programme, which is exclusively to develop new technology to the agro-climatic conditions of state, but also due to research efforts of other states, where the indirect transfer takes place. The authors estimated that an increase of Rs.1000 in state research resource would increase future production to an extent of Rs.6600 directly and plus Rs.1300 due to associated extension programmes of the state. Further, they estimated that a rupee increase on research spending by other states in the major geo-climatic region would yield an income stream of Rs.800 to the state. Finally, the authors concluded that despite the time lag in which the income streams from research investment requires 8 or more years to be fully realized. The internal rate of return to investment in research would be very high.

Kupfuma (1991) examined the role of research and extension in improving the productivity of maize in Zimbabwe from 1932 to 1990 through an evaluation of the payoffs to research and extension investments and an analysis of the institutional environment under which the technology generation and transfer occurred. The rate of return to maize research and extension investments was 43.50 per cent which is almost three times the rate of return to capital investments in the private sector. The benefits were mainly captured by consumers in

the form of lower food prices and large scale farmers through favorable and discriminatory price and marketing policies. The institutional analysis revealed that the productivity of the maize research team was due to the provision of adequate research budget, low staff turnover and attractive salaries and working conditions. The future effectiveness of technology generation and transfer efforts in the marginal areas would depend on the ability of the research and extension departments to recruit, reward and retain gifted scientists, maintain political transparency and maintenance of a public research and extension system since private firms have no incentives to work on programmes whose benefits cannot be internalized.

Sarathi Acharya (1992) computed the rates of returns for different crops in different regions of the country. The study analysed the sources of variation in the rates of return. A variable profit function was estimated with a view to determine the impact of input prices on profits and the consequent supply response of the farmers. The high value crops and controlled irrigation regions often continue to yield better returns compared to coarse grains and pulses. Intercrop variation was more pronounced than interstate variation. Both input subsidies and output prices influenced the rates of return. The crops, which used more inputs and are marketed, tend to accrue higher returns. The profit function estimates suggested that the output supply price elasticities were higher for rainfed crops than to irrigated and carefully nurtured ones. The input price elasticities show that the variable profit is affected most by human labour cost followed by bullock labour cost and then other material input costs. It was evident that the Indian agriculture is still of subsistence type using extensive manual/animal inputs.

Chavas and Cox (1992) applied non parametric productivity analysis in modelling technical progress as a function of public and private research expenditures. The results indicated that 30 years lags are required to fully capture the effects of public research expenditures

in US agricultural productivity. Compared to public research, private research had a stronger influence on farm productivity in the short term but a smaller influence in the long term. The internal rate of return for public research (0.28%) was observed to be higher vis-a-vis private research (0.17%).

Makki and Tweeten (1993) analysed the impact of research and extension (public and private), commodity programmes and prices on The United States agricultural productivity using Almon lag scheme for years 1930 to 1990. The effect of research and extension on productivity was significant and the pay-off was very high. Commodity programmes and prices had a modest impact on productivity.

Rao and Gulati (1994) observed that there has been a significant rise in the total factor productivity in agriculture, accounting for over 50 per cent of output growth in the post-green revolution period. Public research and extension have been the major sources of increase in the productivity, including a very high rate of return to investment in research and extension. The unit cost of production for rice and wheat were declining significantly. However, the share of capital costs had increased and that of labour decreased. The study pointed the scope for further reduction in unit costs and for greater employment generation through regionally broad-based growth. As the growth rates of yields under the seed-fertilizer technology reach a plateau, the tools of biotechnology offer possibilities for breaking these barriers, especially in the unfavourable agro-climatic regions. Removal of subsidies will send the correct economic signals to save on chemical inputs to encourage environment friendly biotechnologies and to conserve water and energy. Adequate intellectual property protection was suggested to encourage private research.

Ananth (2004) conducted a study on returns to investment on agricultural research in major field crops of Karnataka state. For the study data were collected from the secondary sources for a period of

25 years (1970-71 to 1994-95). The study revealed that the agricultural research investment registered a growth rate of 14.7 per cent per annum during the period of 25 years. The cropwise analysis showed that the growth in research investment was highest for tur (15.10%) followed by sunflower (10.45%), groundnut (8.8%) and ragi (7.5%) in real terms. The total factor productivity index showed increasing trend in the case of rice, ragi, cotton and sugarcane. The decreasing trend was noticed in the case of tur and sunflower. The study also revealed that the returns on the agricultural research investment were highest in rice followed by sugarcane, ragi, cotton and jowar. The returns were negative in the case of tur, groundnut and sunflower.

Mrunthyunjaya et al. (2004) studied the impacts of selected technologies refined under NATP. In their study to estimate the economic benefits of the technologies upgraded/ developed under National agricultural technology project (NATP) they used economic surplus model. The model has been applied in a closed economy framework with the assumption of no spillover effects. The data regarding technology and economic parameters were used to estimate economic surplus generated by a technology. The researchers collected the technological data from the principal investigators of the selected projects/technologies with the help questionnaire and the data on economic variables were obtained from published sources. The NPV of incremental benefits from the selected technologies/projects ranged from Rs. 34 million for hybrid vegetables to Rs. 264 million for IPM. The benefit- cost ratios were 7.7 and 2.1, respectively for IPM and hybrid vegetables. The IRR for these technologies ranged from 19 to 43 per cent. The study concluded that returns to investment on dissemination of available technologies are enormous and therefore should receive immediate attention.

Chand *et al.* (2011) revealed that investment on research was a highly paying proposition. The overall internal rates of return to public

investment in agricultural research during the period 1975 to 2005 turned out to be 29% for rice, 38% for wheat , 28% for maize, 39% for jowar, 31% for bajra, 34% for gram, 57% for arhar, 18% for groundnut, 20% for rapeseed & mustard and 39% for cotton. The study suggested that further investments on research will generate significant returns.

Chand *et al.* (2012) in their study on “Total Factor Productivity and Returns to Public Investment on Agricultural Research in India” revealed that the returns to investment on agricultural research have been at 42 per cent. The study found that about one-fourth growth in the output of wheat and cotton, one-fifth in case of pearl millet and around one-eighth in paddy and maize each had been achieved due to investments on agricultural research. In the year 2005-06, contribution of research in crop output was at 10.4 Mt for wheat and 6.3 Mt for rice. In monetary terms, the contribution of research in the value of the nine selected crops has been computed as Rs 1552 crore. The study suggested a higher allocation of resources for development of agriculture in the country and attainment of national food and nutritional security.

METHODOLOGY

III METHODOLOGY

This chapter deals with the description of the study area, selection of sample respondents, sampling techniques adopted, nature and sources of data, various tools and techniques employed in analyzing the data. At the end of the chapter, some of the important concepts and terms used in the study are defined and explained to facilitate a clear understanding of the issues with which the current investigation is concerned.

Karnataka is the major sunflower producing state in the country and the release of country's first hybrid sunflower was from the University of Agricultural Sciences, Bangalore UAS (B). Hence, the present study was undertaken in Karnataka. In this chapter the background information of the study area, sampling framework, database and method of analysis are presented under the following headings:

3.1. Description of the study area

3.2. Selection of the study area and data base

3.3 Analytical tools and techniques

3.1 Description of the study area

In India, Karnataka state stands first both in area and production of sunflower constituting 53.77 per cent of the total area and 35.73 per cent of the total production in the country. In Karnataka, the top 7 districts viz. Raichur, Chikkaballapur, Chikmagalur, Chitradurga, Tumkur, Davanagere, Bijapur and Belgaum together account for 85 per cent of the area under sunflower and account for 90 per cent of sunflower produced in the State.

The University of Agricultural Sciences, Bangalore, has the jurisdiction over twelve southern districts viz., Bangalore rural, Bangalore urban, Kolar, Chikkabalapur, Tumkur, Chitradurga,

Mysore, Mandya, Shimoga, Chikmagalur, Hassan, Kodagu and Dakshina Kannada. The study is confined to The University of Agricultural Sciences, Bangalore, UAS (B) jurisdiction, of which Chikkaballapur, Chitradurga, and Chikmagalur districts were selected for the study based on the area and production. The adoption of technologies released from AICRP on sunflower was higher in these areas compared to other districts.

3.1.1 Location

Chikkaballapur district was carved out of the pre-existing Kolar district in 2007. The town of Chikkaballapur is approximately 56 km north of Bengaluru (formerly Bangalore), the silicon valley of India. Chikkaballapur has a high elevation located in the center of the Nandi Hills region. "Panchagiri" is a common descriptor of Chikkaballapur as it is surrounded by 5 picturesque hills among which Nandi Hills is the famous one and lies between coordinates: 13.430N latitude and 77.720E longitude. It is surrounded by Ananthapur district of Andhra Pradesh on the north east, Bangalore Rural district to west, Kolar on south east and Tumkur to west. The district is situated at 3,002 feet (915 meters) above the mean sea level.

Chitradurga district is situated between Coordinates: 14.23°N latitude 76.4° E longitude and surrounded by Davanagere and Bellary districts on the north, Ananthapur district of Andhra Pradesh on the east, on southeast and southwest by Tumkur and Chikmagalur districts and on the west and northwest by Shimoga district. Chitradurga city is situated at the center of Karnataka which is about 200 Kms, to the northwest of Bangalore city. The district is situated at 3365 feet above the sea level.

Chikmagalur district is situated at 12°54'42" and 13°54'53" North latitude and between 75°04'46" and 76°21'50" East longitude and altitude of 1119 meters. Its average elevation above the mean sea



Fig 3.1. Map of Karnataka showing study districts

level is 6243 ft. Its greatest length from the west is about 138.4 km and from north to south 88.50 km. It is bounded on the east by Tumkur district, on the south west by Western Ghats, on the north east by Chitradurga district and on the north by Shimoga district and in the west by western Ghats, which separates it from Dakshina Kannada (South Canara) and Udupi districts.

3.1.2 Land utilization

Chikkaballapur district has a total geographical area of 4, 04,501 hectares out of which, area under forest is 49,704 hectares (12 per cent). Land which is unavailable for cultivation amounts to 31,933 hectares (7.98 %) and barren land accounts for 8.48 per cent. While the net sown area is 1, 70,698 hectares (42.20 %) and the area under irrigation is about 41,311 hectares (10.21 %)

The total geographical area of Chikmagalur district is 7201 sq km. Out of this 28 percent (1900 sq km.) area is covered by forest. The net sown area of the district in 2009-10 was 2,96,500 ha out of which 35,400 ha was irrigated (Table 3.3). The important crops of the district are coffee, arecanut, ragi, paddy, maize, jowar, coconut, sugarcane, sunflower, cotton, pepper, cardamom, banana and pulses. Cropping intensity is 109% and average land holding size is 0.53 hectares

Chitradurga has a total geographical area of 770702 hectares. Out of which area under forest cover is 73719 hectares. Land unavailable for cultivation is 51243 ha and the cultivable waste land is 21615 ha. Total fallow land of the district is 132722 ha and the net sown area is 459939 ha.

3.1.3 Demography

The total geographical area of Chikkaballapur district is 4254 Sq.Km. As per 2011 Census, it has a population of 12, 54,377, which constitutes 2.05 percent of the state's total population. It occupies

the 23rd rank in terms of area and 22nd rank in terms of population size. The population comprises of 6,37,504 males and 6,16,873 females. The total literacy rate in Chikkaballapur district is 70.08 percent, with male literacy being 78.36 percent and female literacy 61.55 per cent.

The total geographical area of Chitradurga district is 8388 Sq.Km. and this area occupies 4.40 percent of state's total area. As per 2011 Census, it has a population of 16, 60,378, which forms 2.72 percent of the state's total population. It occupies the 9th rank in terms of area and 17th rank in terms of population size. The population comprises of 8, 43,411 males and 8, 16,967 females. The total literacy rate in Chitradurga district is 73.82 percent, with male literacy of 81.37 percent and female literacy of 66.05 per cent.

The total geographical area of Chikmagalur district is 7201 Sq.Km. As per 2011 Census, it has a population of 11, 37,753. This constitutes 1.86 percent of the state's total population. It occupies the 10th rank in terms of area and 25th rank in terms of population size. The population comprises of 5,67,483 males and 5,70,270 females. The total literacy rate in Chikmagalur district is 79.24 percent. The Male literacy was 85.66 percent and female literacy was 72.88 percent.

3.1.4 Rainfall, Weather and Soil

Chikkaballapur district is endowed with excellent agro climatic conditions which are conducive for cultivation of horticultural crops. The weather conditions of the district are dry and hot during summer. Its average normal rainfall ranges from 678 to 750mm. On an average it receives rains on 48 days in a year. The soils in the district are red loamy and lateritic, with shallow depth, well drained, medium rich in plant nutrients which are congenial for growing major food, commercial and horticultural crops such as banana, grapes, chili, tomato, beans, carrot and sunflower.

The influence of climate and rainfall on the agriculture is important as farming predominantly depends upon these natural factors. The climate of this district, which is in the south-west part of the Deccan plateau is marked by hot summer months, low rainfall lasts till about the beginning of June, then after the district comes under the influence of the retreating monsoon or post monsoon period. The Chitradurga district comes under the rain shadow region of the Deccan plateau. The average annual rainfall of the district is 574 mm. The district is generally dry with temperatures ranging from 17° C in winter to 41° C in summer. Chitradurga district has faced 59 droughts in the last 100 years.

The Chikmagalur district receives an average rainfall of 1925 mm per annum. The rainy season extends from June to September. The highest rainfall is received during the month of August. October and November may be termed the post monsoon or retreat monsoon season. The temperature increases rapidly after February. April is generally the hottest month with the maximum temperature at 39° C and the mean daily minimum at 16° C. Nights in May are hotter than in April. The district is having red loamy soils, black and lateritic soils.

3.1.5 Description of the sample taluks

Gauribidanur, Hiriyuru and Kadur taluks are selected from Chikkaballapur Chitradurga and Chikmagalur districts respectively.

3.1.6 Land utilization pattern

Among the sample taluks, total geographical area and area under forest cover is highest in Kadur followed by Gauribidanur and Hiriyuru (14 per cent, 11 and 10 percent of geographic area of the taluk respectively). But, per cent of gross cropped area to net sown area is highest in Gauribidanur taluk (122%) followed by Kadur (120.01%) and Hiriyuru (116.24%).

3.1.7 Major crops

Vegetables, horticultural, food and commercial crops like tomato, beans, sugarcane, ragi and sunflower are the major crops in Gauribidanur. But, in recent years maize is occupying considerable area. In the case of Kadur, per cent area under food crops is 53.27, horticultural crops area was 32.29 percent of total land area. In Hiriyuru taluk the main crops are maize, ragi, sunflower, onion vegetables and coconut. Gauribidanur taluk is characterized by more diversified cropping system.

3.2 Selection of the study area and data base

3.2.1 Study area: Three major districts Chikkaballapur, Chitradurga and Chikmagalur districts of Karnataka were selected for the present study. The selection of districts was purposive based on the area and production as well as adoption of technologies released from AICRP on sunflower from UAS (B).

3.2.2 Sampling design: A Multistage random sampling procedure was employed for the selection of the sample farmers. Chikkaballapur, Chitradurga and Chikmagalur districts were chosen for the study. Further, within each district one taluk was selected based on the same criterion used in selection of districts. Gauribidanur, Hiriyuru and Kadur taluks were chosen from Chikkaballapur, Chitradurga and Chikmagalur districts respectively. From each taluk, a cluster of villages was chosen. The ultimate sample of farmers numbering 50 from each taluk was chosen randomly.

3.2.3 Data base

A structured schedule was prepared and pre tested before it was administered to the respondent farmers. The schedule covered general information on sunflower farmers, their asset position and details of sunflower crop production in terms of input usage, costs, income etc.

Chikkaballapur district

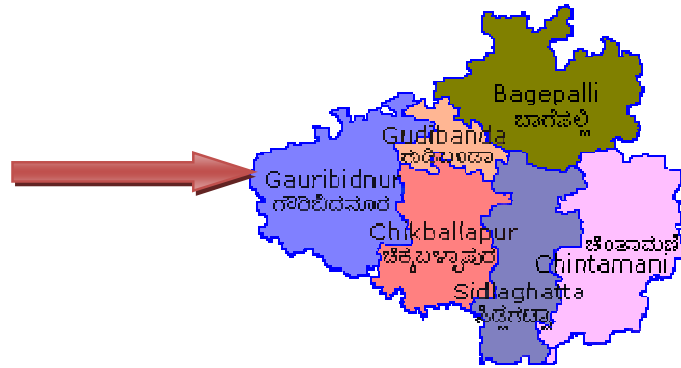


Fig 3.2. Map of Chikkaballapur district showing study taluk

Chitradurga District

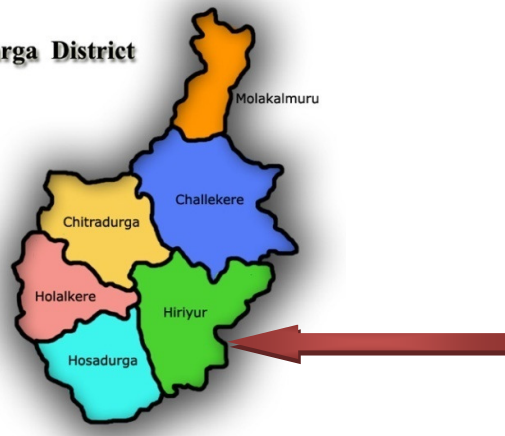


Fig 3.3. Map of Chitradurga district showing study taluk

Chikmagalur District

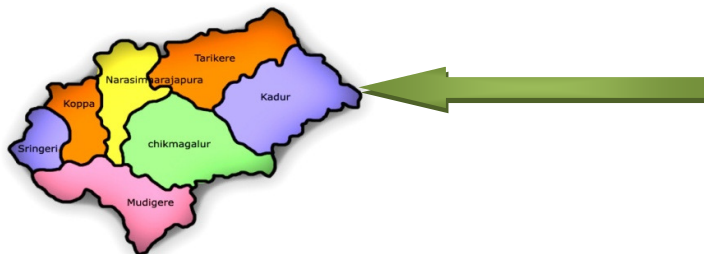


Fig 3.4. Map of Chikmagalur district showing study taluk

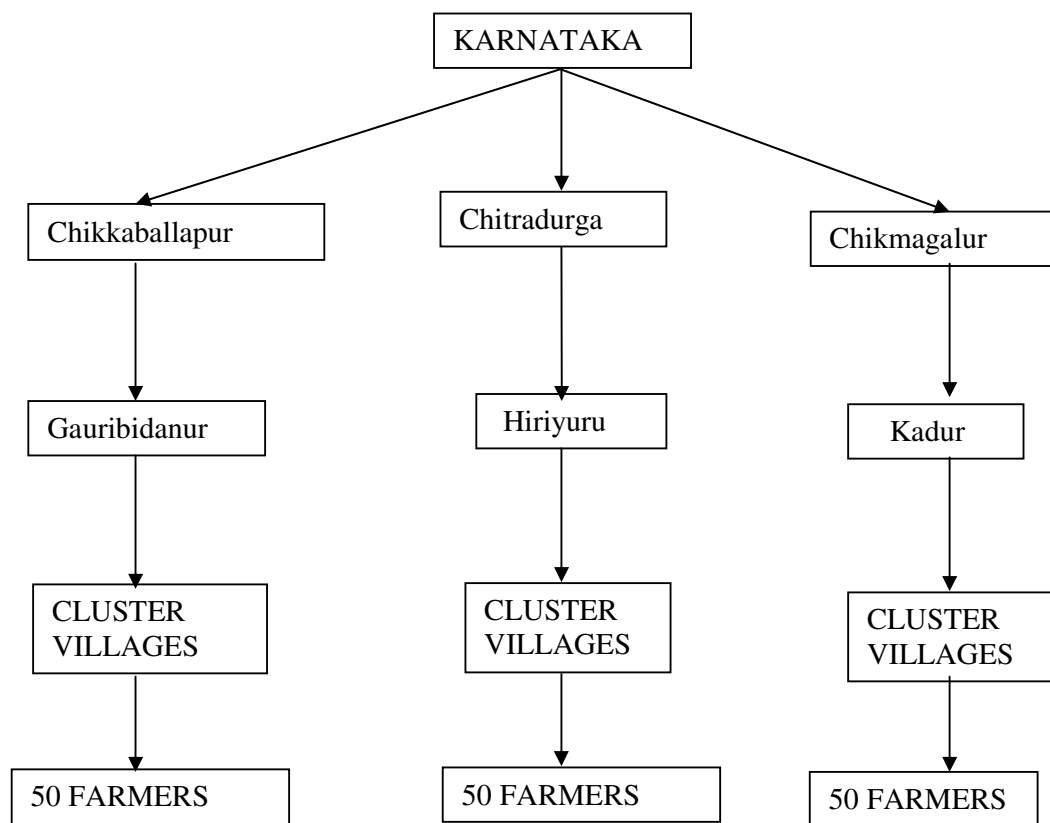


Fig 3.5. Sampling Design Employed



PLATE 1: Interaction with farmers in Gowribidanur



PLATE 3: Interviewer collecting data from the respondent

The district wise time series data on area, production and productivity of sample districts as well as for whole state, for growth rate analysis were collected from Directorate of Economics and Statistics, Government of Karnataka, Bangalore, for the period from 1980-2011. Farm-level data on yield, use of inputs and their prices for sunflower crop grown in the state during the period 1990-91 to 2010-11 were taken from the “Farm Management Section”, Department of Agriculture, Government of Karnataka. State-level data on cost of cultivation and yield taken from the “Farm Management Section”, Department of Agriculture Government of Karnataka were used to estimate the total factor productivity (TFP). The missing year data on inputs and their prices were computed using interpolations in trends of the available data.

For the analysis of returns to research investment on sunflower, the investment made on agricultural research on sunflower by the All India Coordinated Research Project (AICRP) on sunflower in UAS (B), was considered as public sector investment on agricultural research. Salaries and allowances of the research staff both scientific and non-scientific, working under (AICRP) on sunflower in UAS (B) was considered. In addition other expenses such as, equipments and fittings, instructional farms staff research was also included while arriving at total agricultural research investment. However expenditure relating to land acquisition was not considered. Data on these variables were collected for the period 1987-2011 from annual budgets records of the UASB. The data on hybrid/varieties released and area under the hybrids were collected from AICRP centre on sunflower in Bengaluru.

To know the backward support to transfer technologies the secondary data on breeder seed production, commercial seed production and private players in sunflower seed production and extension activities conducted etc were collected. Support, subsidies and programmes on sunflower by government were collected from



PLATE 2: Field day organized by AICRP centre on sunflower, Bangalore in Chikballapur district



PLATE 4: KBSH-53 hybrid of sunflower released by AICRP centre, Bangalore

different sources such as AICRP centre on sunflower Bengaluru, Karnataka State Seed Certification Agency, Karnataka State Seeds Corporation, National Seeds Corporation and from Department of Agriculture, Government of Karnataka.

3.3 Analytical tools/techniques

The following tools were used for the analysis of data

3.3.1 Exponential growth model

Growth rates for area, production and productivity of sunflower grown in Karnataka state were computed for the period 1980-2010 and these were divided into three sub periods and whole period based on pre, post and present impact of hybrids on area, production and productivity. For irrigated area also growth rates were computed for the period 1990-2010. Several functional forms were used to estimate the growth rates of the selected economic variables based on the nature of data. Finally exponential growth model was selected for this purpose.

The exponential model is of the following form.

$$Y = a b^t e \dots \dots \dots (1)$$

Where,

Y= Dependent variable for which the growth rate is estimated (area, production and productivity of sunflower)

a= Intercept

b= Regression coefficient

t= Time variable

e= Error term

The exponential growth rate was obtained from the logarithmic form of the equation as below

$$\ln y = \ln a + t \ln b$$

The per cent exponential growth rate (g) was derived using the relationship

$$g = (\text{Anti ln of } b - 1) \times 100$$

3.3.2 Economics of sunflower crop cultivation

To study the economics of sunflower crop cultivation, tabular analysis was used. Different concepts of costs and returns used in the study are presented in this section. It could be noted here that farmers of this region were more familiar with using acre as the unit of measuring the land area instead of hectare. Accordingly, in the present study all calculations pertaining to the economics of crops were made on per acre basis.

3.3.2.1 Input and cost concepts

The total costs were divided into two broad categories:

- a. Variable Costs
- b. Fixed Costs

a. Variable costs: The variable costs included cost of seeds, manure, fertilizers, wages of human and bullock labour, plant protection chemicals, irrigation, interest on these variable costs, repair and maintenance charges and the farm supplied inputs, They were valued at prevailing market prices

b. Fixed costs: These included depreciation on farm implements and machinery, interest on fixed capital, land revenue and rental value of land.

The measurement and definitions of fixed cost components are as bellow.

- i. Depreciation charges:** Depreciation on each capital equipment and machinery owned by the farmers and used for land cultivation was calculated for individual farmer based on the purchase value using the straight line method.

Purchase value – Junk value

Annual depreciation = -----

Useful life of the asset

The average life of the asset as ascertained through consultation with farmers was used in the computation of the depreciation. The depreciation cost of equipment was apportioned to the crop based on its percentage use.

- ii. Interest on fixed capital:** Interest charges on fixed capital were calculated at the rate of nine per cent, as the fixed deposits in commercial banks would fetch this rate of interest. The items considered under fixed capital are implements and machinery.
- iii. Land revenue:** Actual land revenue paid by the farmers to the government was considered.
- iv. Rental value of land:** The prevailing rental value of the land in the study area was considered separately for irrigated and dry lands.
- c. Total Cost of cultivation:** It is the sum of variable costs and fixed costs and expressed on per acre basis.
- d. Ratio of external to internal resources:** It was worked out by taking the value of external resources which are brought from outside the farm for which payment is made. These were seeds, fertilizers, hired labourers, plant protection chemicals etc., which are used in the crop production.

3.3.2.2 Output and returns:

- i Gross returns:** Returns obtained by multiplying the output of the crop with the value of the output prevailing in the market. It included the returns from the main and by-products calculated at actual price or imputed at those prices if the products were used for self consumption.
- ii Net returns on variable costs:** It is the gross returns minus variable costs.
- iii Net returns on cost of cultivation:** It is the gross returns minus variable costs plus fixed costs.
- iv Returns per rupee of investment :** Worked out by taking the ratio of gross return to cost of cultivation.

$$\text{Return per rupee of investment} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

3.3.2.3 Break-even analysis

Break-even analysis is a technique used to determine the level of production at which farmer realizes neither profit nor loss. It is the minimum level of production required to recover costs.

Break even output

$$TR=TC$$

$$Y \times P_y = TC$$

$$Y = TC / P_y$$

Where,

Y- Break even output (Quintals),

TC =Total Cost per acre

P=Price per Quintal of sunflower

3.3.3 Total factor productivity

Increased use of inputs will allow the agricultural output to move along the production surface. The use of modern inputs will induce an upward shift in the production function to the extent of the technological change embodied in them. The total factor productivity (TFP) concept, which implies an index of output per unit of total factor inputs, measures shift in output properly, holding all inputs constant. Thus, TFP measures the amount of increase in total output which is not accounted for by the increase in total inputs (Kumar and Rosegrant, 1994). Farm harvest prices are used to aggregate the outputs. Inputs included in the input index are labour, bullock labour, seed, manure, fertilizers, pesticides, irrigation and depreciation. Inputs are aggregated using the factor shares on appropriate weights.

Total output, total input, total factor productivity and input price indices are calculated as given below:

Total output index (TOI) –

$$TOI_t / TOI_{t-1} = \pi_j \left(\frac{Q_j^t}{Q_j^{t-1}} \right)^{(R_j^t + R_j^{t-1})^{1/2}}$$

Total input index (TII) –

$$TII_t / TII_{t-1} = \pi_i \left(\frac{X_i^t}{X_i^{t-1}} \right)^{(S_i^t + S_i^{t-1})^{1/2}}$$

Total factor productivity index (TFPI) –

$$TFPI_t = \left(\frac{TOI_t}{TII_t} \right) \times 100$$

Input price index (IPI) –

$$(S_{it} + S_{it-1})^{1/2}$$

$$IPI_t / IPI_{t-1} = \pi_i \left(\frac{P_{it}}{P_{it-1}} \right)$$

Where,

- R_{jt} - is the share of output 'j' in total revenue
- Q_{jt} - is output 'j'
- S_{it} - is the share of input 'i' in total input cost
- X_{it} - is input 'i'
- P_{it} - is price of input 'i', all in period 't'

By specifying $TOIt-1$, $TIIt-1$ and $IPIt-1$ equal to 100 in the initial year, the above equations provide the total output, total input, total factor productivity and input price indices for the specified period 't'.

The TFP is the impact of input cost and output due to technological advancement in the agricultural crop sector. Total factor productivity is a ratio of total output index to the total input index or the value of total output to the total input cost multiplied by 100 or expressed in percentage over the years. Here, the total factor productivity is an indicator of impact of output due to research and extension over and above the input or factor contribution to the total output.

3.3.4 Returns to research investment

Changes in output other than that generated by changes in inputs can be induced by research, extension, human capital, infrastructure, price, policy and climatic factors. As an input into

public investment decisions, it is useful to understand the relative importance of productivity enhancing factors in determining productivity growth.

Several approaches were used to assess the returns to research investment on sunflower. The concept of total factor productivity (TFP) is widely used for this purpose. The TFP index is regressed on sunflower research investment per hectare of area and year, which is a linear trend variable. The estimation can be undertaken using a fixed effects approach for the pooled cross section and time series data set. Using the elasticity of TFP with respect to research investment, one can estimate the value of marginal product (additional product value) of research investment (R). Another approach used is Economic surplus approach proposed by Evenson and Pray (1991). However both the approaches could not be used for the present study due to data limitations and inappropriateness of economic surplus approach for the present case. This is because behavior of prices of sunflower oil seed is masked by import of palm oil. Hence, producer surplus impact of sunflower technology is not fully captured, as area under sunflower is declining steadily over the years, despite the release of new hybrids in the country. Therefore, an alternative approach was used focusing only the breeder seed production and associated package of practices/ technologies released by the AICRP centre, Bangalore.

In this approach data on breeder seed produced by AICRP centre on sunflower in UASB were collected and arrived at commercial cultivated area of sunflower by multiplying breeder seeds in seed chain (shown in table 3.1) under UASB supplied seeds to farmers. For this area which is under jurisdiction of UASB the yield per ha was obtained by averaging the yield of UASB jurisdiction districts. The total output was arrived at total production by multiplying area and average yield.

By multiplying the price with production we arrived at total value of product and this value is multiplied with actual TFP of respective years to get value of output related to TFP. The value of sunflower output so derived was used for estimation of IRR. In addition, the cost incurred on sunflower research over the years was also considered to estimate returns to research investment.

Table 3.1: Multiplication of breeder seed in the chain

Sl.No	1 kg breeder seed	
1	Foundation seed area	Foundation seed production
	0.40 ha	200kg (2qtl.) @5qtl/ha
2	Certified seed area	Certified seed production
	40 ha	20,000 kg (200qtl.)
3	Commercial area	Commercial production
	4000 ha	28000 qtl. @ 7qtl./ha

Source: AICRP centre on sunflower UAS, Gkvk. Bengaluru

Returns to research investment in sunflower was assessed in terms of internal rate of return (IRR). IRR reveals the incremental returns every time period for an incremental research investment on sunflower research. The IRR was estimated as below.

$$IRR = \sum_{t=1}^n \frac{B_t - C_t}{(1+d)^t} = 0$$

Where,

IRR – Internal rate of return

B_t – Benefit in years ‘n’

C_t – Cost in years ‘n’ (research investment)

d – Discount rate

3.3.5 Analysis of backward linkage to support sustenance of technologies transferred to farmers.

In the study an attempt is made to know the backward linkage support to the sustenance of sunflower technologies at farm level. Backward linkage support was analysed in terms of magnitude of breeder seed and certified seeds production, outreach activities of AICRP and state department of agriculture and discipline wise technologies released by AICRP.

RESULTS

IV RESULTS

The data collected from the primary and secondary sources were analyzed using economic and statistical tools described in the previous chapter. The results obtained are presented in this chapter under following headings.

4.1 General socio-economic characteristics of sample respondents

4.2 Analysis of growth rates in area, production and productivity of sunflower in Karnataka

4.3 Economics of cultivating sunflower at farm level

4.4 Total factor productivity of sunflower in Karnataka

4.5 Returns to research investment on sunflower crop in Karnataka

4.6 Backward and forward linkage support for sunflower in Karnataka

4.1 Socio-economic characteristics of sample respondents

Table 4.1 presents the socio-economic characteristics of sample sunflower growers. Various variables studied under the subheading socio-economic status include family size, occupation and family type of the respondents. The average family size of the respondents was 5.3 members. With regard to the family composition it consisted of 1.1 adult males (20.75 per cent), 1.2 adult females (22.64 per cent) and 3 children (56.61 per cent) respectively. For a majority of the sample respondents main occupation was agriculture (90.67%) and for 9.33 per cent of respondent's agriculture was not main occupation but still cultivated sunflower. Majority of the sample sunflower grower's family type was nuclear in nature with 85.33 per cent of sample growers belonging to this group and the joint families formed 14.66 per cent of the total sample farmers.

Table 4.1: Socio-economic characteristics of sample respondents in Chikkaballapur, Chitradurga and Chikmagalur districts

Sl. No.	Particulars	Sample respondents	
		Number	Per cent
1.	Family size		
	a. Adult males	1.1	20.75
	b. Adult females	1.2	22.64
	c. Children	3.0	56.61
	Total	5.3	100.00
2.	Occupation		
	a. Main (agriculture)	136	90.67
	b. Agriculture as subsidiary occupation	14	9.33
	Total	150	100.00
3.	Family type		
	a. Joint	22	14.66
	b. Nuclear	128	85.33
	Total	150	100.00

4.1.1 Educational profile of sample respondents

The educational status of the sample farmers of the study area are presented in Table 4.2. In the case of Chikkaballapur district, 30 per cent of the sample farmers were illiterates (15 out of 50 respondents). In the literate category, majority of respondents (46 %) had primary and high school education followed by 18 per cent of respondents having college and above education level. Interestingly there were six per cent of respondents with agricultural degree in Chikkaballapur district. In the case of Chitradurga district, 36.00 per cent farmers were illiterates. Fifty per cent of farmers had primary and high school level of education and only 12 per cent had college and above education level. In Chikmagalur 18 per cent of respondents were illiterate farmers. In the literate category 44 per cent of farmers had been to primary and high school and 38 per cent of farmers had college and above level of education.

4.1.3 Size of holding and irrigation sources

The size of holdings and the sources of irrigation are presented in Table 4.3 the average size of land holdings of the respondents was 4.47, 6.62 and 4.9 acres in Chikkaballapur, Chitradurga and Chikmagalur districts, respectively. In Chitradurga and Chikmagalur districts, dry land accounted for a larger area of 4.32 acres (65.25%) and 2.83 acres (57.75%), respectively. However in the case of irrigated land holdings, Chikkaballapur ranked first with 2.64 acres (59.06%) followed by Chitradurga 2.04 acres (30.81%) and the lowest irrigated area was in Chikmagalur at 1.98 acres (40.40%). Fallow land was highest in Chitradurga at 0.26 acres (3.92%) and the lowest in Chikkaballapur district at 0.05 acres (1.11%). Bore well was the major source of irrigation as it accounted for 87.5 per cent in the Chikkaballapur district. Tank cum bore well was the next major source of irrigation accounting for 21.21 per cent, 7.95 per cent, in

Table 4.2: Educational profile of sample respondents in Chikkaballapur, Chitradurga and Chikmagalur districts

Particulars	Chikkaballapur		Chitradurga		Chikmagalur	
	No. of farmers	Percent	No. of farmers	Percent	No. of farmers	Percent
Illiterate	15	30.00	18	36.00	9	18.00
Primary and high school	23	46.00	25	50.00	22	44.00
College and above	9	18.00	6	12.00	19	38.00
Agriculture graduates	3	6.00	1	2.00	0	0.00
Total	50	100.00	50	100.00	50	100.00

Table 4.3: Average size of holding and irrigation source of sample respondents in three sample districts

Particulars	Chikkaballapur		Chitradurga		Chikmagalur	
	No of acres	Percent	No of acres	Percent	No of acres	Percent
Dry/Rainfed land	1.78	39.82	4.32	65.25	2.83	57.75
Irrigated land	2.64	59.06	2.04	30.81	1.98	40.40
Fallow land	0.05	1.11	0.26	3.92	0.09	1.83
Total land	4.47	100	6.62	100	4.9	100
Source of irrigation						
Tank	0.12	4.54	0.00	0.00	0.30	15.15
Bore well	2.31	87.5	1.03	50.49	1.26	63.63
Tank cum bore well	0.21	7.95	0.10	4.90	0.42	21.21
Canal	0.00	0.00	0.91	44.60	0.00	0.00

Chikmagalur and Chikkaballapur, respectively. Canal irrigation was the main source of irrigation in Chitradurga at 44.60 per cent.

4.1.2 Assets and Livestock Position

The total value of assets including livestock amounted to Rs 113670 and Rs 107082 per household in Chikkaballapur and Chitradurga districts respectively, however it was lower at Rs 90721 in Chikmagalur (table 4.4). Out of these assets, tractor, power tiller and thresher occupied the lion's share of Rs 48800 (42.93%) and Rs 47500 (44.35%) in Chikkaballapur and Chitradurga districts, respectively and in the case of Chikmagalur district it was Rs 39453 (43.48%). The value of irrigation pump sets was highest in Chikkaballapur district at Rs 14600 (12.84%) followed by Rs 13248 (12.37%) in Chitradurga district and lowest in Chikmagalur district (Rs 8068 or 8.89%). The value of livestock (at prevailing market prices) was the next major component of total assets by the sample farmers. The value of assets and livestock was Rs 34825 and Rs 31980 for Chikkaballapur and in Chitradurga districts respectively with corresponding shares of 30.63 and 29.86 percentage in the total assets where as it was Rs 24654 in Chikmagalur district with a percentage share of 27.17 in the total assets.

4.2 Growth rates in area, production and productivity of sunflower

With an intention of capturing the growth rates in area, production and productivity of sunflower in Karnataka, the exponential growth functions were fitted for the period 1980-81 to 2009-10. The growth rates for three sub periods and overall periods are presented in Table-4.5. During the three sub periods 1980 to 1990, 1991-2000 and 2001-2010, the state registered a growth rate of 32.07, -5.82 and 5.91 per cent in area, 28.58, -7.90 and 3.52 percent in production and -2.10, -2.19 and -2.25 percent. The first two sub periods had registered a significant growth. In third sub period area,

Table 4.4: Assets and livestock position of respondents in the three districts (Rs per household)

Particulars	Chikkaballapur		Chitradurga		Chikmagalur	
	Amount	Per cent	Amount	Per cent	Amount	Per cent
Tractor/power Tiller/Thresher	48800	42.93	47500	44.36	39453	43.48
IP Sets	14600	12.85	13248	12.38	8068	8.90
Other implements	15445	13.59	14354	13.40	18546	20.44
Current value of live stock	34825	30.63	31980	29.86	24654	27.18
Total	113670	100	107082	100	90721	100

Table 4.5: Exponential Growth rates of area, production and productivity of sunflower all seasons 1980- 2010

Years	Particulars	Growth Rate (%)
1980-1990	Area	32.07**
	Production	28.58**
	Productivity	-2.10
1991-2000	Area	-5.82**
	Production	-7.90**
	Productivity	-2.19
2001-2010	Area	5.91
	Production	3.52
	Productivity	-2.25
1980-2010	Area	6.15**
	Production	5.61**
	Productivity	-0.50

Note: ** indicates significant at 5%

production as well as productivity found non-significant. It is clear from the table that the area, production and productivity for all three sub years were non-significant. During the overall period from 1980-2010, the state had registered a positive significant growth of 6.15 percent in area, and 5.61 percent in production. However, the productivity growth was non-significant during all the periods.

4.2.1. Growth rates in area, production and productivity of irrigated sunflower

The results of exponential growth rate analysis on area, production and productivity of irrigated sunflower of Karnataka state from 1990-1991 to 2009-2010 are presented in table 4.6. In the state, a significant growth was observed both in production (4.61%) and productivity (2.00%). However the growth rate in area (2.52%) was positive but non-significant growth.

4.3. Economics of sunflower production at farm level

Details of economics of sunflower production are presented in Table 4.7. The total cost of cultivation of sunflower was highest in the Chikkaballapur district which was Rs 15059 followed by Chikmagalur district at Rs 14509 and the Chitradurga district at Rs 13787. The total variable cost of cultivation of sunflower was highest in Chikkaballapur district with Rs 12641 (83.94% of total costs) where as in Chikmagalur and Chitradurga districts it was Rs 12441 (85.74%) and Rs 11525 (83.59%) respectively. The seed cost was highest in the case of Chikmagalur at Rs 626 (4.31%) followed by Chitradurga district where it was Rs 620 (4.49%); the lowest was in the case of Chikkaballapur district at Rs 446 (2.96%). The cost of fertilizers was the highest in the case of Chikkaballapur district with Rs 1573 (10.44%) and lowest in Chitradurga district at Rs 1348 (9.77%). Labour and machine, which formed the major portion in the cost of cultivation of sunflower was the highest in the case of Chikmagalur district at Rs 7227 (49.81%), and the lowest in case of

Table 4.6: Exponential Growth rates of area, production and productivity of sunflower irrigated 1990- 2010

Years	Particulars	Growth Rate (%)
1990-2010	Area	2.52
	Production	4.61**
	Productivity	2.00**

Note: ** indicates significant at 5%

Chitradurga district (Rs 6998 or 50.75%). The irrigation cost was highest in case of Chikkabalapur district at Rs 1080 (7.17%) and Rs 850 (6.16) in Chitradurga district, whereas it was only 5.71 per cent in the Chikmagalur district. The total fixed cost was highest in Chikkabalapur district at Rs 2418 (16.06%) followed by Rs 2262 (16.41%) and Rs 2068 (14.26%) in Chitradurga and Chikmagalur districts respectively. Among the three districts, cost of cultivation was highest in Chikkaballapur at Rs 15059 (100%) followed by Chikmagalur (Rs 14509 or 100%) and the lowest in Chitradurga at Rs 13787 (100%).

The average yield of sunflower was highest in the case of Chikkaballapur district with 8.2 quintals per acre (Table 4.8) followed by Chikmagalur district in which it was 7.9 quintals. The Chitradurga district recorded the lowest yield of 7.5 quintals per acre. The gross return was the highest in the case of Chikkaballapur district at Rs 24600 per acre where as it was the lowest in the case of Chitradurga district at Rs 20520. The net return over variable cost was also highest in the case of Chikkaballapur district with 11959 per acre and lowest in case of Chitradurga district with Rs 8995. The net return over all costs was the highest in Chikkaballapur district at Rs 9541 and the lowest in case of Chitradurga district (Rs 6733). The ratio of returns per rupee invested was highest in case of Chikkaballapur at 1.61 followed by Chikmagalur at 1.57 and the lowest at 1.48 in the case of Chitradurga district. The break even yield was almost same in Chikkabalapur district (5.00quintals) and Chikmagalur district (5.01quintals) and was about 4.83 quintals in Chitradurga district.

4.3.1 Extent of per acre inputs use and the extent of external versus internal resource use in cultivation of sunflower

The Table 4.9 displays use of inputs as well as labour in physical units. In the case of Chikmagalur per acre seed usage was highest (2.50kg) among three sample districts. This was 25 percent more than the recommended dosage and in the case of

Table 4.7: Cost of cultivation of sunflower in the three sample districts Rs/Acre

Particulars	Chikkaballapur	Chitradurga	Chikmagalur
Seeds	446 (2.96)	620 (4.49)	626 (4.31)
Farm yard manure	1865 (12.38)	1256 (9.11)	1718 (11.84)
Fertilizers	1573 (10.44)	1348 (9.77)	1530 (10.54)
Plant protection chemicals	69 (0.45)	93 (0.67)	114 (0.78)
Machine charges	2192 (14.55)	2345 (17.00)	1984 (13.67)
Animal labour	1012 (6.72)	828 (6.00)	1429 (9.84)
Family labour charges	2094 (13.09)	1456 (10.56)	1573 (10.84)
Hired labour charges	1912 (12.69)	2369 (17.18)	2241 (15.44)
Irrigation cost	1080 (7.17)	850 (6.16)	841 (5.79)
Interest on working capital@7%	398 (2.64)	360 (2.61)	385 (2.65)
Total variable cost Cost (A)	12641 (83.94)	11525 (83.59)	12441 (85.74)
Land revenue	20 (0.13)	20 (0.15)	20 (0.14)
Depreciation	363 (2.41)	342 (2.48)	352 (2.42)
Rental value of land	1350 (8.96)	1223 (8.87)	1011 (6.96)
Interest on fixed capital@9%	685 (4.54)	677 (4.91)	685 (4.72)
Total fixed cost(B)	2418 (16.06)	2262 (16.41)	2068 (14.26)
Total cost (A+B)	15059 (100.00)	13787 (100.00)	14509 (100.00)

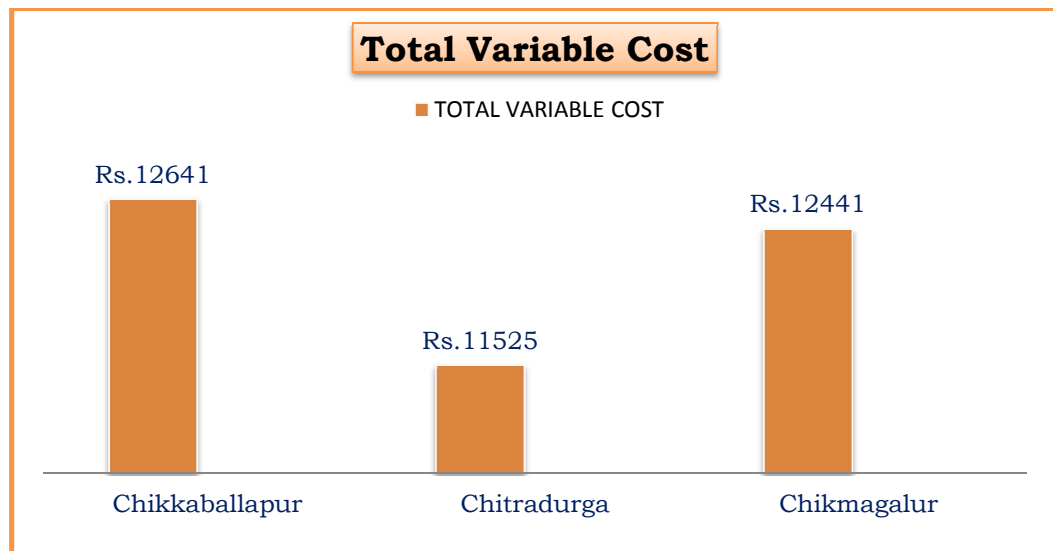


Fig.4.5: Total Variable Costs in Sunflower Production

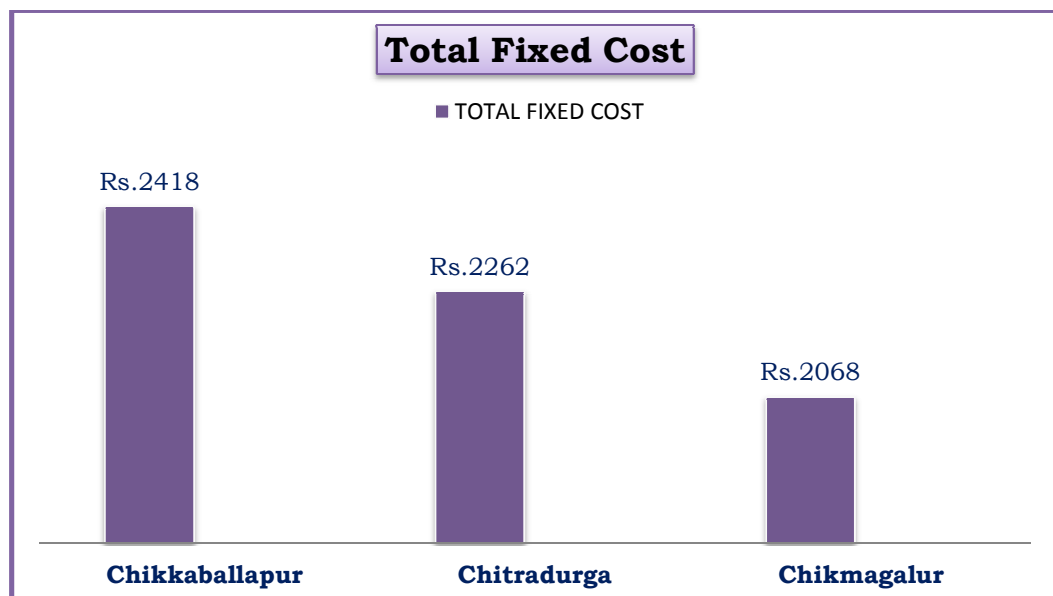


Fig.4.6: Total Fixed Costs in Sunflower Production

Table4.8: Returns from sunflower in the three districts Rs/Acre

Particulars	Chikkaballapur	Chitradurga	Chikmagalur
Yield/acre in quintals	8.20	7.5	7.9
Cost of production/ quintal	1836.46	1838.26	1836.58
Gross returns	24600	20520	22910
Net returns over variable cost	11959	8995	10469
Net returns over all costs	9541	6733	8401
Net returns per rupee of cost	0.63	0.48	0.57
Break even yield	5.01	4.83	5.00

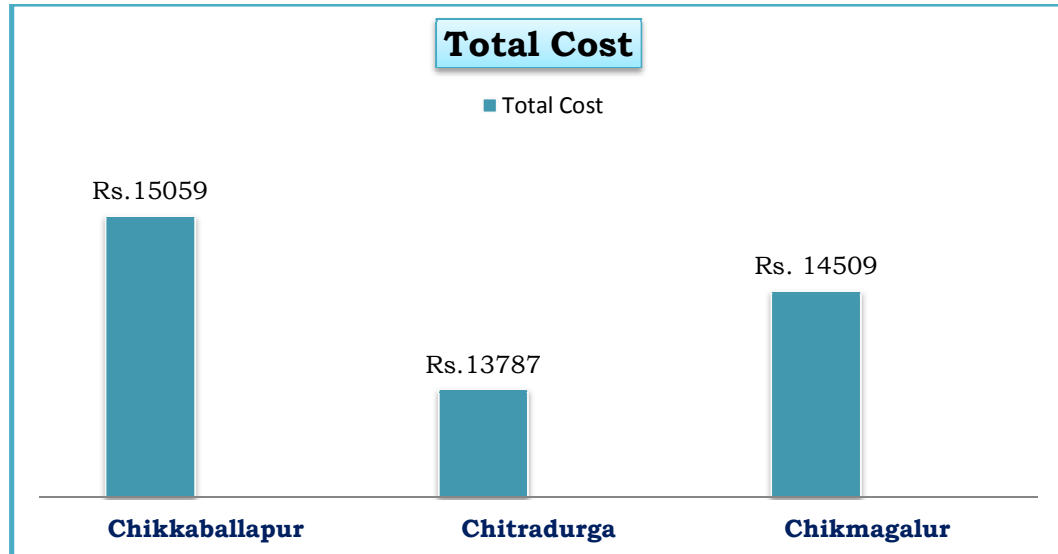


Fig.4.7: Total Cost in Sunflower Production

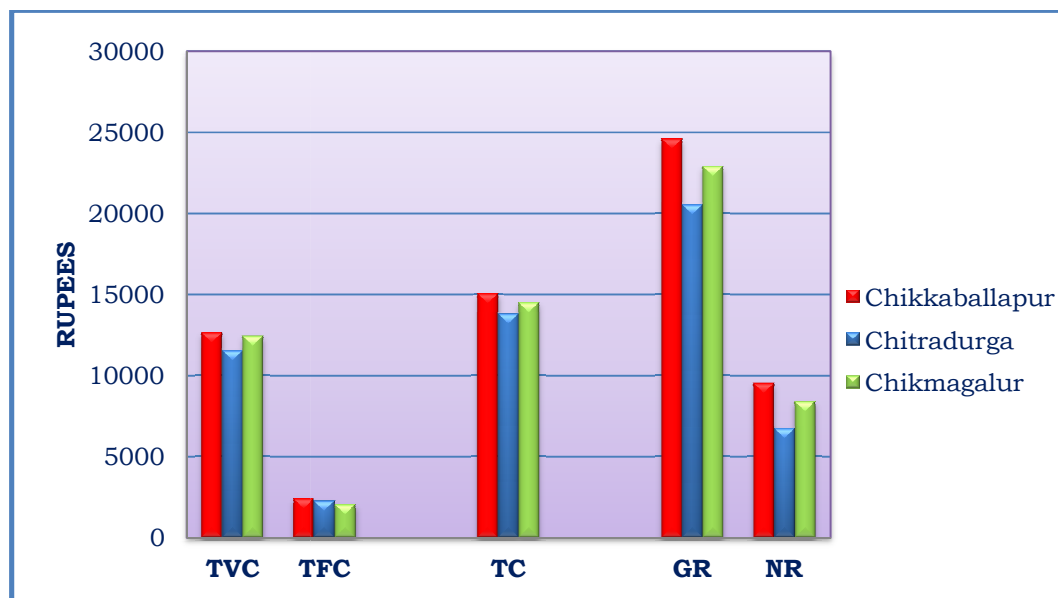


Fig.4.8: Economics of Sunflower Production

Table 4.9: Extent of per acre inputs use in cultivation of sunflower

Particulars	Units	Chikkaballapur	Chitradurga	Chikmagalur
Seeds	Kgs	2.03	2.48	2.50
Farm yard manure	Tonnes	1.86	1.25	1.71
Fertilizers	Kgs	N:53 P:48 K:25 Gypsum:10 Boron:10 Zinc:10	N:41 P:38 K:28 Gypsum:10 Boron:5 Zinc: 0	N:48 P:36 K:20 Gypsum:10 Boron: 0 Zinc: 0
Plant protection chemicals	Liquid in lts	0.5	0.7	0.8
Machine	hours	5.48	5.86	4.96
Bullock labour	Pairs/day	04	03	06
Labour	Man days	Men:09 Women:28	Men:07 Women:34	Men:13 Women:22

Table 4.10: Extent of external versus internal resource use in sunflower among sample respondents Rs/Acre

Particulars	Chikkaballapur	Chitradurga	Chikmagalur
1. Internal resources in value			
FYM	1865 (16.70)	1256 (12.17)	1718 (15.31)
Labour	3685 (33.01)	3065 (29.71)	3452 (30.78)
	5550 (49.71)	4321 (41.89)	5170 (46.0)
2. external resources in value			
Seeds	446 (3.99)	620 (6.01)	626 (5.58)
Fertilizers	1573 (14.09)	1348 (13.06)	1530 (13.64)
Plant protection chemicals	69 (0.61)	93 (0.90)	114 (1.01)
Labour	3525 (31.57)	3933 (38.12)	3775 (33.66)
	5613 (50.29)	5994 (58.11)	6045 (54.00)
3. Total resources	11163	10315	11215
4. Ratio of external to internal resources	1.01	1.38	1.16

Note: Figures in parentheses indicate percentage to the total

Chikkaballapur it was on par with recommended package of practices (2.03kg). FYM use was highest in Chikkaballapur (1.86 tons) followed by Chikmagalur (1.71 tons). Similar trend was seen in the case of fertilizer use. But in machinery and implements usage, Chitradurga district stood first with 5.86 machine hours. In the case of labour, involvement of men was less compared to women in all the three districts.

From Table 4.10 we can notice that internal resources were well utilized in the case of Chikkaballapur district at 49.71 per cent with family labour constituting major share (33.01%). About 46.00 per cent was the total amount of internal resource used in Chikmagalur and 46 per cent in Chitradurga district. External resource usage was highest in Chitradurga at 58.11 per cent. In that the major share was from using hired labour and in the Chikmagalur district the extent of external resource use was 54.00 per cent. The ratio of external to internal resource use was highest (1.38) in Chitradurga district and lowest (1.01) in Chikkaballapur district.

4.3.2 Yield gap in sunflower per ha in qtls

That term yield gap is used to describe the enormous gulf between the crop yields obtained by the most successful farmers and the least successful and in turn compared with research experimental yields. Table 4.11 depicts yield levels and yield gaps in sunflower crop in the state. The yield gap between potential and average farmers' yield in the state was 3.40 qtl.per ha in rainfed area and in the case of irrigated areas the yield gap was higher at 10.66 qtl. Per ha. The yield gap between frontline demonstrations conducted by AICRP centre and average farmers yield in the state was 1.40 qtl.per ha and in irrigated area 8.16 qtl. The potential yield of sunflower crop as of package of practices given by AICRP centre is 10 qtl./ha and 25 qtl./ha in rainfed and irrigated conditions, respectively.

Table 4.11: Yield gap in sunflower per ha in qtls

Particulars	Rainfed	Irrigated
A) Over all average yield in Karnataka	6.60	14.34
B) Yield observed in Front line demonstrations of AICRP	8.00	22.50
C) Potential yield as of package of practices	10.00	25
Yield gap-1(B-A)	1.40	8.16
Yield gap-2(C-B)	2.00	2.50
Yield gap-3(C-A)	3.40	10.66

Table 4.12: Summary of comparative economics of sunflower hybrids over earlier hybrids

years	Cost of cultivation in Rs	COC in real terms*	Yield /ha(qtl)	Price per (qtl)	Gross returns (Rs)	Gross returns in real terms* (Rs)	Net returns in Real terms*(Rs)
1991	5169	12021	8.36	1010	8444.6	19636	7615
2003	10824	11515	12.34	1709	21089	22435	10920
2010	16370	11777	14.38	2212	31809	22883	11107

* Costs and returns incurred in the previous years were brought to the current period by compounding these values based on the whole price index.

4.3.3 Summary of comparative economics of sunflower hybrids (KBSH44, 53) over earlier hybrids

A detailed summary of comparative economics of sunflower hybrids is presented in Table 4.12. The cost of cultivation of sunflower crop in real terms in the year 1991 was Rs 12021 and Rs 11777 in 2010. The yield per ha was 8.36 qtl in the year 1991 and 14.38 qtl in 2010. Price realised per qtl of output was Rs 1010, 1709, and 2212 in the years 1991, 2003 and 2010 respectively. The net returns realised was highest in the year 2010 at Rs 11107 and lowest in the year 1991 at Rs 7615. This shows that the profitability of sunflower hybrids released in recent years is higher.

4.4. Total factor productivity of sunflower during the period 1990-91 to 2010-11

Sunflower is an important oilseed crop of Karnataka accounting for about 50 per cent of gross cropped area of the country. From the table 4.13 it is observed that the TFP for sunflower varied from 1.13 in 1991-92 to 1.06 in 2010-11. The TFP growth had fallen to 0.62 in the year 1994-95, and again in the year 2002-03 to 0.65. The TFP was very low (0.52) during the period 2008-09. The highest TFP was observed during the year 1995-96 (2.08) and the average TFP for the 21 years was 1.15. The output growth of sunflower Ranges from 1.27 in 1991-92 to 0.99 in 2010-11. The output growth has fallen to 0.61 in 2000-01 as well as in 2006-07 and reached lowest in 2008-09 (0.50). The highest output growth (2.30) was observed in the year 2007-08. The average output index for twenty one years was 1.12. In the case of input growth wide fluctuations were observed. It has decreased from 1.12 in 1991-92 to 0.94 in 2010-11. The highest (2.07) input growth was recorded in the year 1994-95. The average input growth of sunflower was 1.02 for the entire 21 years.

**Table 4.13: Total factor productivity of sunflower in Karnataka
from 1990-91 to 2010-11**

Observation years	Total input growth	Total output growth	Total factor productivity
1990-91	1.00	1.00	1.00
1991-92	1.12	1.27	1.13
1992-93	0.96	1.32	1.37
1993-94	0.58	0.63	1.09
1994-95	2.07	1.29	0.62
1995-96	0.53	1.11	2.08
1996-97	1.24	1.21	0.98
1997-98	0.81	0.91	1.13
1998-99	1.16	0.88	0.76
1999-00	1.10	1.45	1.32
2000-01	0.84	0.61	0.73
2001-02	1.39	1.93	1.39
2002-03	1.09	0.71	0.65
2003-04	0.57	1.13	1.99
2004-05	0.93	0.85	0.92
2005-06	1.02	1.11	1.09
2006-07	0.91	0.61	0.67
2007-08	1.13	2.30	2.05
2008-09	0.96	0.50	0.52
2009-10	1.06	1.63	1.54
2010-11	0.94	0.99	1.06
Average	1.02	1.12	1.15

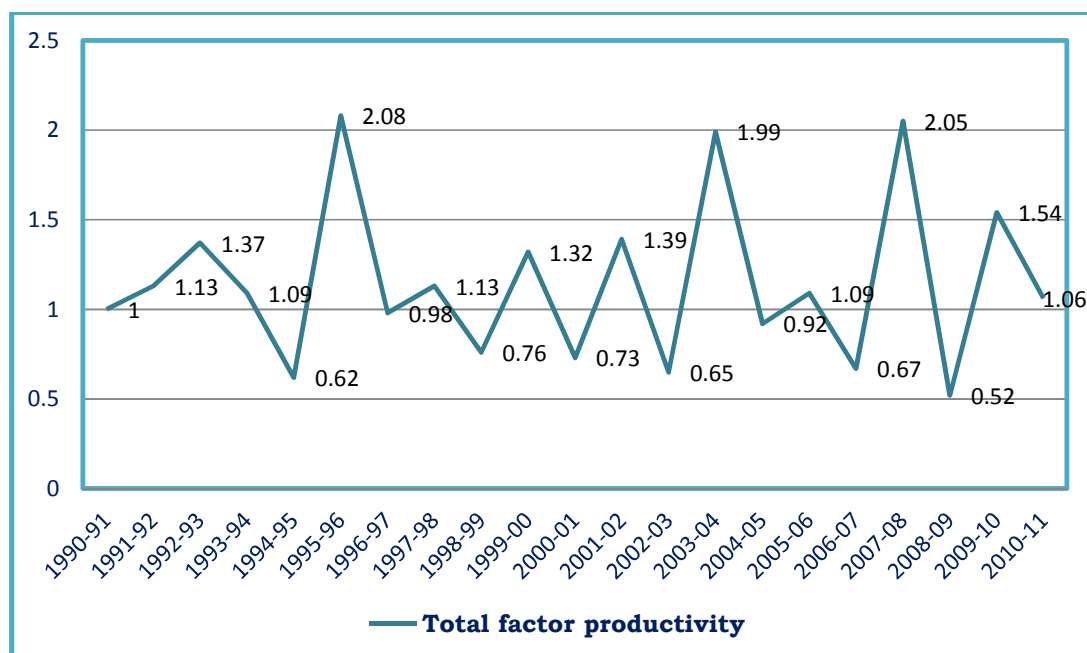


Fig.4.1: Total Factor Productivity of sunflower from 1990-91 to 2010-11 in Karnataka

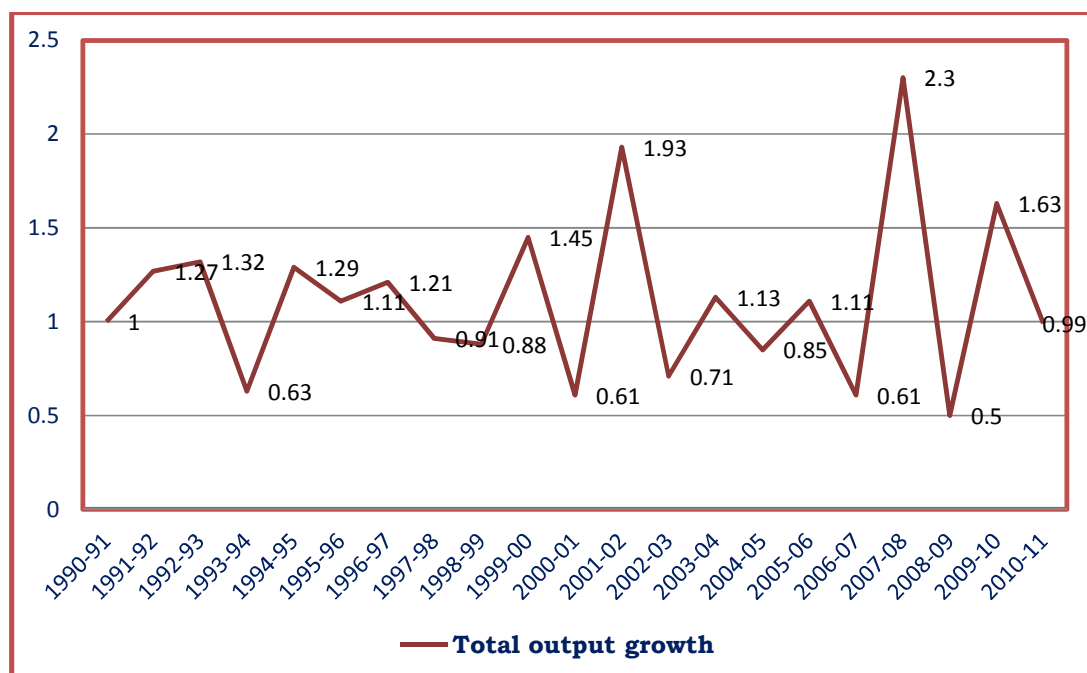


Fig.4.2: Total Output Growth of sunflower from 1990-91 to 2010-11 in Karnataka

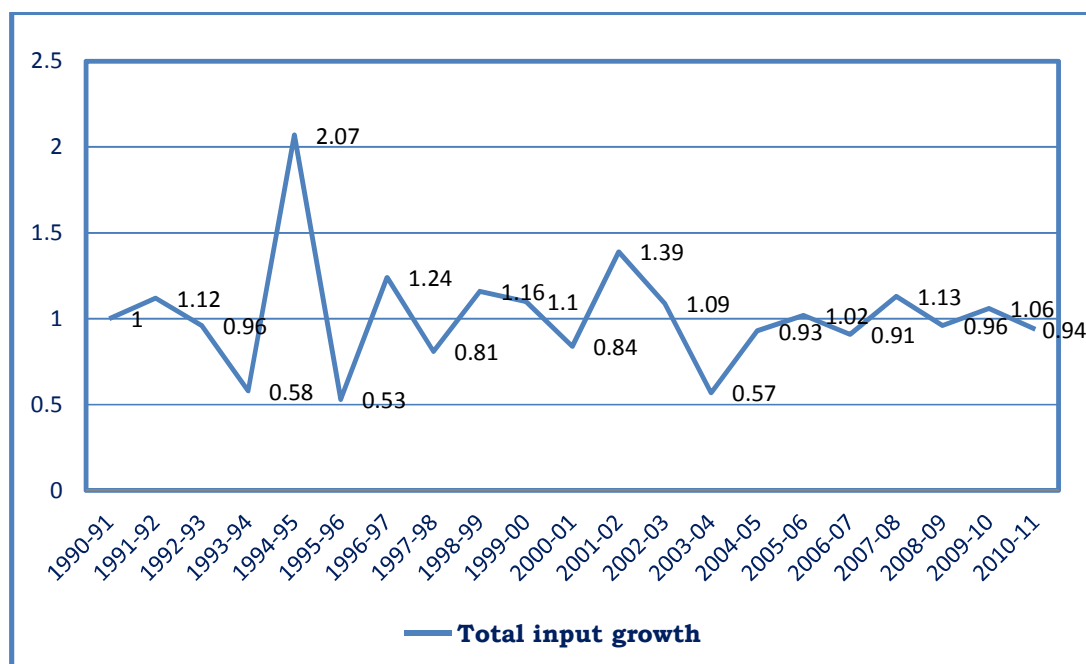


Fig.4.3: Total Input Growth of sunflower from 1990-91 to 2010-11 in Karnataka

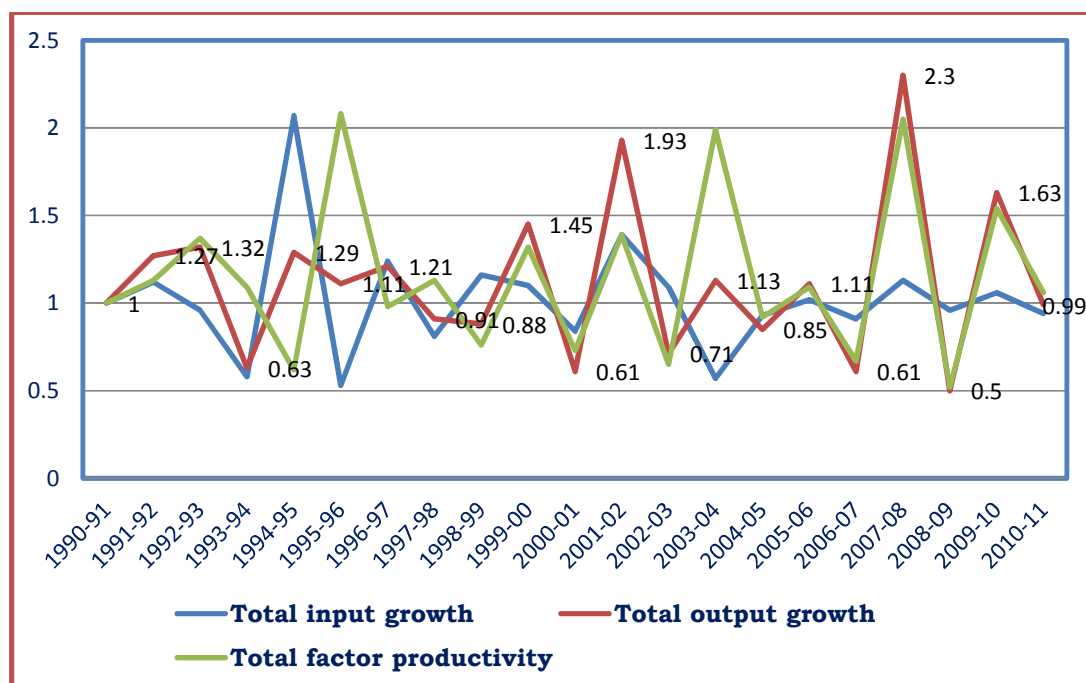


Fig.4.4: Total Output Growth, Total Input Growth and Total Factor Productivity of Sunflower from 1990-91 to 2010-11 in Karnataka

4.5 Rate of return to research investment on sunflower crop in Karnataka

Sunflower has gained importance as an oil seed crop only during the 80s and 90s with release of the country's first hybrid BSH-1 in the state. Sunflower has made rapid strides in the state with an area of 10 lakh hectares. Research investment in sunflower has been on the increase from Rs. 30.39 lakhs in the year 2001-02 to Rs. 73.91 lakhs in the year 2010-11. However, the TFP growth in sunflower has been not much satisfactory. The results presented in Table 4.14 show that in the crop year 2001-02, the additional returns were 5.26 crores and the highest additional returns was obtained during 2003-04 which is 58.93 crores. The negative returns (-73.96 crores) was seen in the year 2008-09. The research expenditure (200.68 Rs per ha) was highest in the year 2009-10 and the lowest in 2005-06 (18.99 Rs per ha). During the 10 year period, in most of the years the research expenditure has not been able to make any dent on TFP leading to lower returns to research investment. In the study period, in most of the years we can see from the Table 4.14 that returns are not much satisfactory. Out of ten years only in six years it has shown positive returns. In aggregate the rate of return to research investment as revealed by the internal rate of return (IRR) was 7.87 per cent. Considering the public good nature of research investment by the government, the rate of return of 7.87 seems to be satisfactory.

4.6 Backward linkages to transfer and support sunflower technologies

Backward linkage in the form of technology support, supply of quality seeds, inputs, plant protection chemicals and adequate extension support are essential for the sustenance of agricultural production including sunflower production.

AICRP at UAS, Bangalore center has established good linkages with Karnataka Oil Seeds Grower Federation (KOF), National Seeds

Table 4.14: Rate of returns to (AICRP) research investment on sunflower in Karnataka

Year	Total Area (lakh ha)	Total Product ion (tons)	Research expenditure (Rs in lakh)	Research Exp. Per hectare (Rs/ha	incremental production (lakh tons)	Addi- tional value (Rs. In crores)	TFP
2001-02	0.25	14294	30.39	121.56	55.32	5.26	1.39
2002-03	0.80	50734	15.64	19.55	-175.74	-23.00	0.65
2003-04	0.56	50387	22.56	40.29	500.15	58.93	1.99
2004-05	0.61	55388	33.10	54.26	-47.02	-6.46	0.91
2005-06	1.08	89100	20.51	18.99	76.00	14.57	1.09
2006-07	0.71	55340	23.20	32.68	-181.63	-40.89	0.66
2007-08	0.77	48310	36.99	48.04	505.66	77.55	1.98
2008-09	0.84	53304	39.41	46.92	-256.87	-73.96	0.53
2009-10	0.38	26192	76.26	200.68	141.88	32.80	1.56
2010-11	0.58	45427	73.91	127.43	25.30	6.58	1.06

Table 4.15: Breeder seed production from AICRP centre on sunflower UAS (B)

Year	Breeder seed production(kgs)
2001-02	6.14
2002-03	19.88
2003-04	13.95
2004-05	15.25
2005-06	27.00
2006-07	17.76
2007-08	19.11
2008-09	20.92
2009-10	9.49
2010-11	14.56
TOTAL	164.06

Source: AICRP centre on sunflower UAS, GKVK, Bangalore

Corporation (NSC), and Karnataka State Seeds Corporation Ltd., (KSSC) to promote the hybrids released by the centre through quality seed production in large quantities. Table 4.15 shows the quantity of breeder seed produced by the Bangalore centre and supplied to different organizations as well as to private companies. The breeder seed production was highest during the year 2005-06 (27.00 kgs) and the lowest production was 6.14 kg s and 9.49 kgs in 2001-02 and 2009-10 respectively.

To promote the hybrids released by the AICRP centre, the centre has conducted many outreach activities, which included 220 front line demonstrations under real farm situations, which serve as one of the major modes of transfer of improved sunflower production technologies. The centre has conducted 11 field days, 10 training programmes, 21 TV and radio talks and participated in *krishimela* (field days) to demonstrate the new hybrids and technologies released by the centre.

In collaboration with the National Seed Project in UAS, Bangalore, the AICRP centre on sunflower in Bangalore is conducting scientist-farmer participatory quality hybrid seed production programmes. Under this program (Seed Village Concept) large scale production and supply of quality seeds have been taken up for popularization and spread of the hybrids released from UAS, Bangalore. Under this programme, in five crop years starting from 2007-08 to 2011-12, the centre has produced 357.1 tons of certified seeds.

As of now AICRP centre on sunflower has released 5 hybrids of which three are recognized as national hybrids among four in the country. This is one of the great milestones in the research by this centre. It has also released 2 varieties and many technological innovations in different disciplines for improvement of the productivity of sunflower.

Table 4.16: Extension activities on sunflower Hybrids conducted by AICRP centre on sunflower UAS (B)

Sl. No	Outreach activities (2002-03 to 2009-10)	No.
1	Front Line Demonstrations (FLD's)	220
2	Field Days organized	11
3	Training Programmes conducted	10
4	TV/Radio Programmes	21
5	Participation in Krishimela/Field days	15

Source: AICRP centre on sunflower UAS, GKVK, Bangalore

Table 4.17: Scientist Farmer participatory quality Hybrid seed production in qtl.

Name of Hybrid	2007-08	2008-09	2009-10	2010-11	2011-12
KBSH-53, KBSH44, KBSH-41, KBSH-1	520	370	1250	925	506

Source: AICRP centre on sunflower UAS, GKVK, Bangalore

Table 4.18: Discipline-wise number of technologies developed and released in sunflower crops by the UAS (B) in Karnataka

Sl no.	Discipline (From time period)	No. of technologies released
1.	Crop improvement (1975-2012)	8
2.	Agronomy (1985-2010)	16
3.	Crop physiology (1995-2010)	6
4.	Entomology (1986-2008)	12
5.	Plant Pathology (1983-2010)	12

Source: AICRP centre on sunflower UAS, GKVK, Bangalore

Table 4.19: Number of varieties developed and released in sunflower in Karnataka (1975-76 to 2012-13)

Sl.No.	Year	Technology
1	1975	EC-68415
2	1978	Morden
3	1980	BSH-1
4	1992	KBSH-1
5	2001	KBSH-41
6	2001	KBSH-42
7	2002	KBSH-44
8	2008	KBSH-53

Source: AICRP centre on sunflower UAS, GKVK, Bangalore

DISCUSSION

V DISCUSSION

Productivity growth is the focus of all development activities. Research and infrastructure development helps to achieve this through a shift in the production function, which does not entail additional use of resources per se to accomplish the increase. The determinants of production or supply are mainly prices, inputs, weather conditions, technology, infrastructure and policies. It is increasingly being felt that technology, infrastructure and policy are emerging as stronger determinants of productivity than prices and inputs as the former facilitate a congenial atmosphere for the achievement of higher productivity, although the productivity is directly influenced by various inputs factors like labour, fertilizer, and chemicals. However, the development of infrastructure facilities and congenial regional and agro-climatic factors will have a complementary effect on material inputs to augment the productivity. Hence, there is an increasing need to quantify the influence of non-material inputs like technology, infrastructure and regional and socio-economic variables on the farm productivity in order to orient policies and prioritize investment for sustained growth of the agricultural sector. The results of the study are discussed in this chapter under the following headings.

- 4.1 General socio-economic characteristics of sample respondents
- 4.2 Analysis of growth rates in area, production and productivity of sunflower in Karnataka
- 4.3 Economics of sunflower cultivation at farm level
- 4.4 Total factor productivity of sunflower in Karnataka
- 4.5 Returns to research investment on sunflower crop in Karnataka
- 4.6 Backward and forward linkages to support technology transfer

5.1.1 Socio-economic characteristics of the respondents.

The socio economic characteristics of the sample farmers are discussed in terms of education status, age and the average family size of the sample farmers from the three districts.

5.1.2 Literacy status of respondents

The education status did not vary too much across the sample farmers in the three districts of the study area. A majority of farmers in Chikkaballapur, Chitradurga and Chikmagalur were literates (70.00 % 64.00 % and 82 % respectively). In the Chikmagalur district, though the literacy level was highest among the three districts, most of the farmers had primary and high school (44.00 percent) and college and above (38.00 per cent) education. In the literate category of Chitradurga district, more number of farmer respondents had primary and high school level education (50.00 per cent) than in Chikkaballapur district (46.00 per cent). It could be seen that more number of the farmer respondents in the Chikmagalur followed by Chikkaballapur had college and above education level because the access to higher education was easier as these respondent villages were nearer to the city premises and as well as family status was better compared to the other district in the sample. About 6.00 per cent of farmer respondents in Chikkaballapur district had agricultural education mainly because of close proximity of villages to UAS (B).

5.1.3 Size of Holding and Irrigation Sources

The average land holding of the sample farmers was 4.47 acres in Chikkaballapur district, 6.62 acres in Chitradurga district and 4.39 acres in Chikmagalur district. This was in proportion with the family size since the family size was higher in Chitradurga district which may be a factor which influenced them to go for cultivating more land. The irrigated area was highest in the Chikkaballapur district with almost 60 per cent of the cultivated area under irrigation, whereas it was only

40.40 per cent in Chikmagalur and 30.81 per cent in Chitradurga districts. The irrigated land contributed higher gross returns and the higher income of the sample farmers. Bore well, as the major source of irrigation was highest among all the three districts because, these areas come under rain fed and dry lands conditions where no other source was existing. Hence, they were more dependent on bore well irrigation. In the case of Chitradurga district canal irrigation contributed 44.60 per cent as a source of irrigation. In case of Chikkamagaluru district tank as an irrigation source contributed 15.15 per cent because in this region average rainfall was higher compared than the other two districts.

5.1.4 Assets and Livestock Position Sample of Farmers

The relative share of the assets and the livestock position across the three districts appears to be same as evident from the table 4.4. But per household position of the asset and the livestock was quite different. The total value of livestock assets in Chikkaballapur district was Rs 113670, in Chitradurga district Rs 107282 and in Chikmagalur district it was Rs 90721. Asset position in terms of tractor, tiller and thresher was higher among farmers in Chikkaballapur and Chitradurga districts which is a sign of higher mechanization than in Chikmagalur. It also highlights the scarcity of labors, hence, farmers turned to mechanization, to overcome the labour problem. In Chitradurga district the value of assets of tractor, tiller and thresher was only Rs 39453 which means per capita availability was lesser. In Chikmagalur, the value of irrigation pump sets per farm was lower because the bore wells were not deep hence, they used motors with lower HP. In the case of Chitradurga and Chikkaballapur districts the bore wells were much deeper so they had to use more HP motors, hence, the value of IP sets was higher in these districts. Current market value of livestock was highest in the case of Chikkaballapur district with Rs 34825, where as it was lowest in Chikmagalur district with Rs 24645 which means the liquidity that

can be realized by live stock was quite low in Chikmagalur than in Chikkaballapur.

5.2 Growth Rates of Area, Production and Productivity of Sunflower in Karnataka State.

Growth rates reveal the progress and importance of crops in the economy of a country. Investment in research and development is mainly aimed at increasing the productivity of sunflower crop by the way of developing new varieties and farm technologies. The AICRP in Karnataka was established in 1972-73 crop year. The first variety released from the Bangalore centre was EC-6841 in 1975 and country's first hybrid in sunflower was released in 1980. Subsequently a number of sunflower hybrids were released in the state by the centre. Normally the impact of research innovation and technologies can be seen with lead effect of 3-5 years as awareness and adoption among farmers may take so much time.

Due to release of high yielding varieties and hybrids, the area in Karnataka under sunflower increased from 37787 ha in 1980-81 to 494099 ha in 2000. However, it started declining later including current decade due to various reasons.

In order to assess the impact of sunflower technologies on area , production and productivity, growth rates were estimated using exponential growth function for four periods namely, 1980-1990 (pre-impact period), 1991-2000 (post-impact period), 2001-2010 as a period marked by increasing import of palm oil and overall period from 1980 to 2010.

As presented in table 4.5 during the first period (1980-1990) area registered an annual growth rate of 32.07 per cent per annum. However, productivity registered a negative growth rate of 2.1 per cent which was statistically insignificant. The total production grew by 28.58 per cent per annum during this period. Thus the total output

was mainly contributed by area growth rather than productivity growth.

During the second period (1991-2000) all economic variables registered negative growth rate with total production registering highest negative growth while productivity decline was slower. Both area and productivity decline were responsible for decline in production. During this period import of edible oil started trickling in which might had an impact on sunflower oil price and consequently on the area and total production of sunflower.

The third period is marked by the impact of palm oil which might have suppressed the demand for sunflower, groundnut and other domestically produced edible oil. In this period best hybrid (KBSH-44) in terms of productivity was released which led to increase in area and total production. However, growth rates were not statistically significant.

For the overall period both growth in area and production of sunflower turned out to be positive with growth rates of 6.15 and 5.61 per cent respectively. However, productivity growth rate was negative, as corresponding coefficient was statistically not significant. At the aggregate, sunflower production in Karnataka state was largely area led growth.

It is interesting to note that from table 4.6 that under irrigated conditions, during all sub-periods, the variables exhibited positive growth rate of 2.52, 4.61 and 2.00 per cent respectively in respect of area, production and productivity. The productivity contributed more than area to the total production under irrigated condition which suggests that sunflower hybrids perform well under irrigated conditions. Thus our hypothesis that there was substantial improvement in the yield of sunflower is realized partially as yield improvement was significantly noticed under irrigated sunflower areas.

5.3 Economics of Sunflower Production

As a preamble to assessment of returns to research investment on sunflower, economics of sunflower production was assessed. The UASB had supplied hybrid seeds to the sunflower growers in Chikkaballapur, Chitradurga and Chikkamagaluru districts of Karnataka. The input use pattern among sunflower growers in these districts is depicted in Table 4.7. The economics of sunflower production is summarized in Table 4.8.

Out of the total cost of Rs. 15059 per acre, variable cost was more than 80 per cent in all the three districts. Among variable costs labour cost was the major one accounting for more than 25 per cent in all the districts. The next important cost was nutrients costs. It was highest in Chikkaballapur district at (12.38% FYM, 10.44% fertilizers) 22.82 per cent followed by Chikkamagaluru district with (11.84% FYM, 10.54% fertilizers) 22.38 per cent of total costs. It was lowest in Chitradurga district with (9.11% FYM, 9.77% fertilizers) 18.88 per cent.

Among fixed costs, the rental value of land was the most important one at 8.96, 8.87 and 6.96 per cent in Chikkaballapur, Chitradurga and Chikmagalur districts, respectively. The total fixed cost accounted for 16.06, 16.41 and 19.26 per cent of total cost of Rs. 15059, Rs. 13787 and Rs. 14509 per acre, respectively in the three districts.

The table 4.8 reveals the summary of economics of sunflower production. The average yield realized by the farmers was higher in Chikkaballapur district at 8.20 quintals per acre. Whereas in Chitradurga and Chikkamagaluru districts farmers realized slightly lower yields of 7.5 and 7.9 quintals per acre. The highest yield in Chikkaballapur district can be attributed to higher degree of adoption of sunflower technologies released by AICRP centre at UASB by farmers. The cost of production per quintal of sunflower was almost

same in the three districts at around Rs. 1836. But gross returns were higher at Rs. 24600 per acre in Chikkaballapur district. It was Rs. 20520 and Rs. 22910 among farmers in Chitradurga and Chikkamagaluru. Net income after meeting all expenditure was highest at Rs. 9541 per acre in Chikkaballapur district. The net rate of return was 0.63, 0.48 and 0.47 in Chikkaballapur, Chitradurga and Chikkamagaluru districts, respectively. The results show that the sunflower production is possible under diverse socio-economic conditions. Hence, the area under sunflower needs to be expanded.

To assess the degree of dependence of sunflower farmers on market for inputs and resources, the ratio of external inputs to internal inputs was computed. The ratio turned out to be 1.01, 1.38 and 1.16 for Chikkaballapur, Chitradurga and Chikkamagaluru districts, respectively. It can be interpreted that for every rupee worth of input supplied by the farm, farmers purchased more than one rupee worth of input/ resources from external sources. This is clear evidence of increase in the dependency of farmers on external inputs. Interestingly, it was on labour input that sunflower farmers depended more on external sources implying scarcity of family labour.

5.3.1 Yield gap in sunflower and Summary of comparative economics of sunflower hybrids

Yield gaps in crops are real and these need to be reduced in the interest of increased and sustainable crop production. The yield gap comprises at least two components. The first component of yield gap (I) is the difference between experiment/research station yield and the potential farm yield. The second component of yield gap (II) is the difference between the potential farm yield and the actual average farm yield (Alam, 2006). The yield gap II is exploitable and can be minimized by deploying research and extension approaches and government interventions, especially institutional issues. Socio-economic and institutional/policy constraints can cause yield gaps

significantly. It is thus necessary that the government addresses the issues seriously and come forward with solutions to the problems to increase productivity by minimizing the yield gaps. Hanson *et al.* (1982) recommended that the government should find solutions to socio-economic and political questions for narrowing the agronomic gap between farmers' fields and the research stations. From table 4.11 we can observe that yield gap was more in irrigated than in rainfed areas. A study by Siddiq (2000) in India showed that yield gap varied between 15.5 and 60 percent with the national average gap of 52.30 percent in the irrigated ecosystem (Siddiq, 2000).

The performance of recently released hybrids of sunflower was superior to earlier sunflower hybrid varieties as revealed by table 4.12. The net income from recent hybrids is higher than that of old hybrid varieties. This is mainly due to improved productivity of recently released hybrids and relatively higher price of sunflower in recent years. Thus our hypothesis that a substantial yield improvement has been observed in sunflower due to hybrid varieties is proved.

5.4 Total Factor Productivity of sunflower in Karnataka

The total factor productivity (TFP) is a measure used to assess the contribution of non-material inputs in the production of a commodity. In the production of a commodity, besides material inputs like seeds, fertilizers, manures etc., non-material inputs like technologies viz., embodied technologies (seed), timely farm operations, infrastructure like roads, markets, suitable information etc. are also used. To a greater extent the productivity of resources is dependent on magnitude of technological innovations adopted by the farmers, markets, better road facilities etc. These largely influence farmers to obtain inputs timely and better marketing (higher price), thereby improvement in the value of output.

In the present study only technologies released by AICRP on sunflower in Karnataka were considered to assess the TFP in

sunflower as described in the methodological content. TFP for the period 1990-91 to 2010-11 was assessed and results are presented in the Table 4.13. The year 1990-91 was considered as the base year. In the year 1992 KBSH-1 hybrid was released for commercial cultivation and in 2001, 2002 and 2008 a number of hybrids were released by AICRP on sunflower in Karnataka. As a result, average productivity of sunflower increased significantly in the state. Besides, these varieties appropriate plant protection, nutrient management and other technologies suitable to hybrid seeds were released. It is hypothesized that these technologies contribute substantially to the production of sunflower in the state.

As depicted in Table 4.13 during the reference period TFP growth was positive within a few years of inception AICRP indicating the contribution of technologies for sunflower production in the state. During the year 1991-92 TFP was 1.14 which can be interpreted that technological, infrastructural factors contributed about 14 per cent to the sunflower output growth. However during the years 1994-95, 1996-97, 1998-99, 2000-01, 2002-03, 2006-07 and 2008-09 contribution of these factors was negative. This may be due to the adverse weather factors as opined by Kumar and Rosegrant (1994) or non-availability of complementary factors in required amounts. The technology can work efficiently if complimentary factors are available at optimal level. The contribution of technologies (mainly varieties/ hybrids and package of practices) was positive on the productivity, as a result the total production of sunflower in Karnataka increased persistently over the years proving our hypothesis that sunflower technologies in Karnataka contributed positively to the production. However, the area under sunflower is declining despite positive contribution of technology. This could be attributed to the large scale import of palm oil which is a substitute to sunflower although impact of palm oil import was not analyzed in the present study. Consequently decline or stagnant prices of edible oils including

sunflower oil might be a causal factor for area shift under sunflower crop to other crops.

5.5 Returns to research investment in sunflower

Under the AICRP, substantial research investment has been made for the development of the sunflower HYVs and hybrid varieties in the state. Besides, the research investment is also made on the development of agronomic, plant protection and other components of package of practices, which are essential for the exploitation of yield potential of hybrid varieties of sunflower. The data presented in the table 4.14 revealed the public research in nominal terms on sunflower under the AICRP in Karnataka. During the year 2001-02 an expenditure of Rs. 30.39 lakh was made on sunflower research under UASB judistraction which worked out to approximately Rs. 121.56 per ha of sunflower crop. During the year 2010-11, the public research investment was Rs. 73.91 lakh and average investment per ha worked out to Rs.127.43 per ha. However, the area under sunflower is exhibiting variations over the years with increasing trend during the first few years of the nineties and then showing a declining trend. The variations in the research expenditure over the years from 2001-2011 per ha basis was due to variations in the area of sunflower crop. The best hybrid KBSH-44 was released and this resulted in rise in area under sunflower in 2006-07. But thereafter the area again started declining. In 2009-10 it was at 0.38 lakh ha compared to previous year's area of 0.84 lakh ha. Consequently output also varied a lot reflecting fully the impact of sunflower research.

Returns to research investment in sunflower was assessed in terms of internal rate of return (IRR). IRR reveals the incremental returns every time period for an incremental investment on sunflower research. Different approaches suggested in the literature were explored to assess the returns to research in investment on sunflower. The important approaches are economic surplus approach and the

method proposed by Evenson and Pray (1991). But the economic surplus approach is inappropriate for the present study because price of sunflower oil seed is masked by import of palm oil. Hence, producer surplus impact of sunflower technology cannot be fully captured as area under sunflower is declining steadily over the years, despite the release of new hybrids in the country. Further if the objective of the investigation is to evaluate total benefits without any regard to the components of economic surplus method, it is appropriate to evaluate aggregate benefits from the new technology. Therefore, an alternative approach was used focusing only the breeder seed production and associated package of practices/technologies released by the AICRP centre Bangalore to assess the aggregate benefits from sunflower technologies.

As depicted in the Table 4.15 AICRP centre Bangalore is producing sunflower breeder seeds over the years. This is distributed to various public and private seed companies to multiply and produce certified seeds for the general cultivation by farmers.

The total value of sunflower output from AICRP centre was evaluated taking into account the total area that could be planted with sunflower hybrid seeds. The value of TFP of the AICRP technologies was evaluated as outlined in the methodology chapter. Using TFP of sunflower, the contribution of AICRP Bangalore centre was evaluated as depicted in the Table 4.14. Based on this, IRR of research investment was worked out

The IRR was about 7.87 per cent, which is the return to research investment on sunflower under AICRP in Karnataka state. The IRR of 7.87 per cent is quite reasonable because the research and technological output is considered as a public good for which expected rate of return would be rather low. Instead of private rate of return, social rate of return is considered which will be usually 2-4 per cent per annum. Therefore it can be inferred that research investment on

sunflower is positive both on social and commercial considerations confirming our stated hypothesis that returns to research investment on sunflower was positive.

5.6 Backward linkages to support sustenance of technologies transferred to farmers

Backward linkage in the form of technology support, supply of quality seeds, inputs, plant protection chemicals and adequate extension support are essential for the sustenance of agricultural production including sunflower production. In the study an attempt is made to know the backward linkage support to the sustenance of sunflower technologies at farm level. Backward linkage support was analysed in terms of magnitude of breeder seed and certified seed production, outreach activities of AICRP and state department of agriculture and discipline wise technologies released by AICRP.

AICRP centre on sunflower at UASB is supplying sunflower breeder seeds to Karnataka State Seed Certification Agency (KSSCA), National Seeds Corporation (NSC), Karnataka Oil seeds Grower Federation (KOF) and private players for the production and distribution of foundation and certified seeds to farmers for commercial cultivation. It could be observed from the table that AICRP Bangalore centre is supplying breeder seeds to the extent of 14.50 kgs for foundation and certified seed production. With 1 kg of breeder seeds, about 20,000 kgs of certified seeds can be produced, this covers an area of 4,000 ha. Thus, with the production of 14.50 kgs of breeder seeds, AICRP could able to meet the requirement of seeds for 58240 ha. However, private seed companies are also into the development of sunflower varieties and supplying the certified seeds to sunflower growers. Thus, it can be inferred that this is some support to the farmers by way of supply of certified seeds through continuously evolving sunflower hybrids.

As far as extension services are concerned, the state department of agriculture is actively engaged in extension role besides supply of

quality seeds through Raitha Samparka Kendras (RSK) and minikit programmes. AICRP center in Bangalore is conducting frontline demonstrations regularly to educate farmers. As indicated in the table 4.16 so far as it has conducted 220 Front Line Demonstrations (FLD) during the period 2002-03 to 2009-10. Besides these AICRP has also undertaken several extension activities such as field days, training programmes, TV and radio programmes etc. Thus, it can be inferred that there is adequate backward linkage support for transfer and sustenance of sunflower technologies in the area operated by AICRP.

SUMMARY

VI SUMMARY

This concluding chapter gives a summary of the findings of present study and the policy implications emerging from it. The policy implications may help planners and policy makers as input for evolving appropriate measures for the development of sunflower crop in the state. Large investments were made on agriculture research in the country with the onset of green revolution during mid-1970s. This helped in the development and promotion of HYV of seeds with fertilizer and irrigation technologies which had a high pay-off and a significant progress was made in food production. Initially, the improved technology was confined to a limited area but after mid-1980s, the country witnessed the spread of improved agricultural technologies to a wider area which continued through the early years of 1990s. However, the productivity growth attained during the decades of 1975-95 could not be sustained in recent years for many crops due to various factors. In recent years, the crop sector has been experiencing diminishing returns to input-use and for several crops there is either deceleration or stagnation in the TFP growth. In some cases, the TFP has even shown a negative growth. This has resulted from a number of factors which need to be addressed.

In addition to research breakthroughs in agriculture, it is necessary that infrastructure development has to be in order to achieve a shift in the production function. It is increasingly being felt that technology, infrastructure and policy factors are stronger determinants of productivity than prices and inputs as the former facilitate a congenial atmosphere for the achievement of higher productivity, although the productivity is directly influenced by various factors like inputs in the form of labour, fertilizer, and chemicals. Hence, various technological, infrastructural, regional and agro-climatic, and socio-economic factors have to be addressed in order to augment the farm productivity, as they are the complementary factors that boost the productivity of primary factors

of production. This calls for measuring the impact of investment in agricultural research to achieve higher productivity levels. The establishment of the All India coordinated research projects (AICRP's) throughout the country has given the much desired impetus for carrying out systematic research in agriculture and solving the problems of farmers at regional level.

Karnataka stands the first in area and production of sunflower in the country, because of its varied agro-ecological, agro-climatic, bio-diversity and soil conditions and resources across the state which suit well for cultivation of sunflower. In Karnataka, there are two All India Coordinated Research Projects on sunflower. These centres are spending public money of more than one crore rupees annually for research in sunflower crop. The research activities in the state have been undertaken on the basis of location and crop specific basis in all districts and agro climatic regions. Keeping above issues in view the study mainly focused on analysis of the productivity aspects of sunflower in the state as influenced by technological innovations, notably in the form of hybrid varieties.

6.1. Specific objectives of the investigation

While the overall objective of the study was to analyse the impact of sunflower technologies from AICRP on the productivity of sunflower in the state, the specific objectives of the study are

1. To estimate productivity improvement of Sunflower due to hybrid technology under AICRP.
2. To asses economic impact of AICRP technologies in sunflower.
3. To quantify TFP of hybrid technologies of sunflower.
4. To assess the returns to research investment on sunflower.
5. To analyze backward linkage to support sustenance of technologies transferred to farmers.

6.2. Data and Methodology

6.2.1 Data

The study was carried out in three important sunflower growing districts of the state, namely, Chikkaballapur, Chitradurga and Chikmagalur. A structured schedule was prepared and pre tested before it was administered to the respondents. The schedule covered general information on sunflower farmers, their asset position and details of sunflower crop production in terms of input usage, costs and income etc. Data were collected from 150 sample sunflower farmers for the crop year 2012-13.

For the analysis of growth performance of sunflower crop in the state, time series data on area, production and productivity of sample districts as well as for whole state were collected from Directorate of Economics and Statistics, Government of Karnataka, Bangalore, for the period from 1980-2011. Farm-level data on yield, use of inputs and their prices for sunflower crop grown in the state during the period 1990-91 to 2010-11 were taken from the “Farm Management Section”, Department of Agriculture, Government of Karnataka. State-level data on cost of cultivation and yield collected from the “Farm Management Section”, Department of Agriculture Government of Karnataka were used to estimate total factor productivity.

For the analysis of returns to research investment on sunflower, the investment made on agricultural research on sunflower by the All India Coordinated Research Project (AICRP) on sunflower in UAS (B), was considered as public sector investment on agricultural research. Salaries and allowances of the research staff, both scientific and non-scientific, working under AICRP on sunflower in UAS (B) was considered. In addition other expenses such as equipments and fittings, instructional farms staff research also included while arriving at total agricultural research investment. Data on these variables were

collected for the period 1987-2011 from annual budget records of the UASB.

The data on hybrid/varieties released and area under these hybrids were collected from AICRP centre on sunflower in Bengaluru. To know the backward support to transfer sunflower technologies, the secondary data on breeder seed production, commercial seed production, private sunflower seed production and extension activities conducted etc were collected. Supporting the form of subsidies and programmes by government were collected from different sources such as AICRP centre on sunflower Bengaluru, Karnataka state seed certification agency, Karnataka state seeds corporation, National Seed Corporation and from the department of agriculture Government of Karnataka.

6.2.2 Methodology

Growth rates were calculated using exponential growth model. To workout the economics of sunflower crop, conventional economic measures were used and costs were categorised as fixed and variable costs. The total factor productivity (TFP) was estimated to measure the contribution of non-material inputs like research, infrastructure and other factors. TFP which is measured as an index of output per unit of total factor inputs indicates the output due to technological and other factors. For this the time series data from the different years were used. Returns to research investment was measured in terms of the internal rate of return (IRR).

6.3 Major findings of the study

The major findings of the current study are summarized below.

- ❖ In the study area, the main occupation of the respondents was agriculture with 90.66 per cent and agriculture as subsidiary occupation for 9.33 per cent.

- ❖ In all three the districts dry land constituted the major part of land holding.
- ❖ Average holding size of farmers belonging to Chikkaballapur district was 4.47 acres, in Chitradurga district it was 6.62 acres and in Chikmagalur district 5.34 acres.
- ❖ Around 70 per cent of the farmers from Chikkaballapur district, 64 per cent of the farmers from Chitradurga district and 82 per cent of the farmers from Chikmagalur district were literates.
- ❖ The farmers from Chikkaballapur district had Rs 113670 worth of assets and live stock. The farmers in Chitradurga had Rs 107082 worth and Chikmagalur farmers had Rs 90721 worth of assets and livestock.
- ❖ The growth rates for sunflower crop in Karnataka state for 1980 to 1990, 1991-2000, 2001-2010 the three sub periods were 32.07, -5.82 and 5.91 per cent in area, 28.58, -7.90 and 3.52 percent in production and -2.10, -2.19 and -2.25 percent (a negative growth rates) for sunflower productivity. The area and production of sunflower in the first two sub periods had registered a significant growth.
- ❖ In third sub period, area, production and productivity was non-significant. During the overall period (1980-2010), the state had registered a positive significant growth of 6.15 percent in area and 5.61 percent in production. However, the productivity growth was non-significant during all periods.
- ❖ The growth rates for area, production and productivity of irrigated sunflower in Karnataka during the period 1990-1991 to 2009-2010 registered a significant growth both in production (4.61%) and productivity (2.00%). However the growth rate in area (2.52%) was positive but non-significant.

- ❖ The total cost of cultivation of sunflower per acre was Rs 15059 in Chikkaballapur. In Chitradurga it was Rs 13787 and in Chikmagalur Rs 14509 per acre.
- ❖ Total variable cost per acre was Rs 12641 in Chikkaballapur district. In Chitradurga and Chikmagalur district it was Rs 11525 and Rs 12441, respectively.
- ❖ Total fixed costs per acre was highest in Chikkaballapur district at Rs 2418, followed by Chitradurga and Chikmagalur with Rs 2262 and Rs 2068, respectively.
- ❖ Net return over all costs for sunflower per acre was Rs 9541 in Chikkaballapur, in Chitradurga and Chikmagalur it was Rs 6733 and Rs 8401, respectively.
- ❖ Net return over variable costs for sunflower per acre was highest in Chikkaballapur at Rs. 11959. In Chitradurga district it was Rs 8995 and in Chikmagalur Rs 10469.
- ❖ The ratio of net return per rupee invested in sunflower was highest in Chikkaballapur (0.63) followed by Chikmagalur (0.57) and Chitradurga (0.48).
- ❖ Break even yield for sunflower was 5.01 quintals, 4.83 quintals and 5.00 quintals per acre in Chikkaballapur, Chitradurga and Chikmagalur districts, respectively. .
- ❖ The seed rate used per acre was highest in Chikmagalur (2.50 kg), followed by Chitradurga at 2.48 kg and Chikkaballapur 2.03 kg per acre.
- ❖ Labour utilization pattern showed that employment of women labour was more in all the three districts with 28 woman days in Chikkaballapur. In Chitradurga and Chikmagalur districts it was 34 and 22 women days, respectively.

- ❖ The Ratio of external to internal resources was highest in Chitradurga district with 1.38. While it was lowest in Chikkaballapur district at 1.01, in Chikmagalur district the ratio was 1.16.
- ❖ The yield gap in sunflower is 3.40 qtl.per between potential and average farmers yield in rainfed areas where as it was 10.66 qtl per ha in irrigated areas in Karnataka state.
- ❖ TFP for sunflower varied from 1.13 in 1991-92 to 1.06 in 2010-11. The TFP had fallen to 0.62 in the year 1994-95, and again in the year 2002-03 at 0.65. The TFP was very low (0.52) during the period 2008-09. The highest TFP was observed during the year 1995-96 (2.08) and the average TFP for the 21 years was 1.15.
- ❖ The output growth of sunflower increased from 1.27 in 1991-92 to 1.63 in 2009-10. The output growth had fallen to 0.61 in 2000-01 as well as in 2006-07 and reached lowest in 2008-09 (0.50). The highest output growth (2.30) was observed in the year 2007-08. The average output index for twenty one years was 1.12.
- ❖ In the case of input growth, lots of fluctuations were observed. It had decreased from 1.12 in 1991-92 to 0.99 in 2010-11. The highest (2.07) input growth was recorded in the year 1994-95. The average input growth in sunflower worked out to be 1.02 for the entire 21 years.
- ❖ It can be inferred that the contribution of sunflower technology to the productivity growth of sunflower has been one of the varying and inconsistent.
- ❖ Research investment on sunflower has been on the increase from Rs. 20.31 lakhs in the year 1990-91 to Rs. 73.91 lakhs in the year 2009-10.

- ❖ The return to research investment in sunflower was evaluated using the measure of internal rate of returns (IRR). The IRR for AICRP centre Bangalore was estimated at 7.87 per cent. This is considered to be a reasonably good rate of return viewing research investment in agriculture as social benefit rather than private benefit.
- ❖ The quantity of breeder seeds produced and supplied to different organizations as well as to private companies was highest during the year 2006-07 (27.00kgs) and the lowest production was 6.14 kgs and 9.49 kgs in 2002-03 and 2010-11 respectively. This was inadequate considering the total area of about 10 lakh ha.
- ❖ To promote hybrids produced the AICRP centre has conducted several outreach activities, which include 220 frontline demonstrations, 11 field days, 10 training programmes, 21 TV and radio talks and 20 *Krishimelas* (Field days) to demonstrate new hybrids released.
- ❖ In collaboration with the National seed project in UAS, Bangalore, the AICRP centre on sunflower in Bangalore has conducted scientist-farmer participatory quality hybrid seed production programmes. Under this 3571 quintals of certified seeds was produced.
- ❖ As of now AICRP centre Bangalore on sunflower has released 5 hybrids, of which three are noted as best performing national hybrids among four in the country.
- ❖ Thus, it can be inferred that there is adequate backward linkage support for sustenance of sunflower production in the state.

6.4 Policy implications

- ❖ The area decline under sunflower could be due to slow rise in prices of sunflower due to import of palm oil, which in turn may act as disincentive to farmers. Therefore, to increase area under sunflower higher level of support prices may be thought of.
- ❖ More than 80 percent of area under sunflower in the state is rainfed, therefore, the productivity levels are very low. To improve the dry land productivity, research initiatives need to be focussed to evolve drought resistant varieties.
- ❖ Yield gaps between potential and farmers' yields are substantially higher due to combination of various constraints such as poor management and economic conditions of farmers. Efforts should therefore be made to minimize the yield gaps through concerted extension activities and programs. This is particularly important as technologies are readily available for irrigated areas but, for rainfed there is a need for redefined focus on drought resistant varieties.
- ❖ Most of the farmers expressed that due to non availability of seeds of AICRP varieties in sufficient quantities, they are looking up to private sector. Therefore seed multiplication and distribution can be taken up on a priority basis by UASB (AICRP) and state department of agriculture and related corporations to meet the demand from farmers.

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APPENDICES

APPENDIX-I

Area, production and productivity of sunflower in Karnataka state from 1980-2010.

year	Area (ha)	Production(tons)	Productivity(Kgs)
1980-81	37787	16270	448
1981-82	97663	42121	454
1982-83	195551	78661	423
1983-84	333827	196284	619
1984-85	444975	236527	559
1985-86	375968	155084	434
1986-87	597834	285629	503
1987-88	1056556	351115	350
1988-89	490524	158378	340
1989-90	580573	235084	426
1990-91	895914	382168	449
1991-92	1191182	508150	449
1992-93	1068506	424591	418
1993-94	1469302	474844	340
1994-95	839542	355049	445
1995-96	1012129	395337	411
1996-97	881124	361536	432
1997-98	928522	258054	293
1998-99	833346	264037	333
1999-00	494099	200697	428
2000-01	477791	231037	509
2001-02	584318	262406	473
2002-03	876592	373937	449
2003-04	1135465	364687	338
2004-05	1271128	528118	437
2005-06	1427435	667511	492
2006-07	1230569	384262	329
2007-08	1025175	493045	506
2008-09	1001015	414007	435
2009-10	794165	251317	333

APPENDIX-II

Area, production and productivity of sunflower irrigated in Karnataka state from 1990-2010.

year	Area (ha)	Production(tons)	Productivity (Kgs)
1990-91	78314	40132	555
1991-92	81236	43714	566
1992-93	233425	145577	656
1993-94	265840	134013	531
1994-95	202537	149493	777
1995-96	200528	126360	663
1996-97	181879	112849	653
1997-98	179209	90754	533
1998-99	153578	74514	511
1999-00	115153	74891	685
2000-01	91437	67642	779
2001-02	109823	91979	882
2002-03	161974	113816	740
2003-04	188050	135390	758
2004-05	266352	214957	849
2005-06	242545	195034	846
2006-07	235112	167529	750
2007-08	216220	184841	900
2008-09	226756	178050	827
2009-10	176202	109381	653

APPENDIX-III

Research investments on sunflower by AICRP centre Bengaluru (Rs in lakhs)

years	Research investment in nominal	Research investment in real (Base year-2003-04)
1989-90	16.66	42.73
1990-91	18.08	42.04
1991-92	20.31	42.32
1992-93	11.78	21.81
1993-94	23.78	41.71
1994-95	16.90	26.83
1995-96	17.11	25.93
1996-97	17.65	25.21
1997-98	13.17	17.57
1998-99	17.11	22.22
1999-00	23.09	27.81
2000-01	17.96	20.64
2001-02	30.39	34.14
2002-03	15.64	16.63
2003-04	22.56	22.56
2004-05	33.10	31.52
2005-06	20.51	18.64
2006-07	23.20	20.17
2007-08	36.99	29.35
2008-09	39.41	30.78
2009-10	76.26	54.86
2010-11	73.91	51.68

**DEPARTMENT OF AGRICULTURAL ECONOMICS
UNIVERSITY OF AGRICULTURAL SCIENCES GKVK, BANGALORE-65**

Schedule

Research Title: “Economic impact of Sunflower production technologies under AICRP in Karnataka”

Name of the researcher:

I. General information

Date of interview:

1. Name of the farmer:
2. Village:
3. Age:
4. Mobile/ phone No:
5. Particulars of family: nuclear family / Joint family:

Particulars	name	Age	Education	Occupation
Male				
Female				
Children				

6. Particulars of land holdings

Sl. No.	Type of land	Owned		Leased in		Leased out	
		Area (Acres)	Market Value of land (Rs.)	Acres (Acres)	Rent paid per season (Rs.)	Acres (Acres)	Rent received per season (Rs.)
1	Dry land						
2	Irrigated land						
3	Current Fallow						
4	Total						

*Give reasons for fallow (migration, labor shortage, alternative employment)

II. Farm inventory

Farm machinery and equipments

Sl. No.	Particulars	Nos.	Current Value (Rs.)	Year of purchase	Income from custom hiring per year (if any)
1	Bullock cart				
2	Sprayers				
3	Power tiller				
4	Tractor				
5	Irrigation pump (IP set)				
6	Vehicle (2 or 4 wheeler)				
7	Farm building				
8	Others				

Live stock

Sl. No.	Type	Nos.	Output (specify kgs, litres...)	Price per kg/litre / specified unit	Cost involved in rearing (specify per month or year etc)
1	Bullock				
2	Cow local				
3	Cow crossbred				
4	She buffalo				
5	Sheep				
6	Goat				
7	Poultry				

III. Source of irrigation

Sl. No.	Source	Yield of well (in inches)	Year of investment	Investment (Rs)
1	Open well/dug well			
2	Bore well(s)			
3	Canal			

For example: Measure the yield of well noting down the time in seconds to fill the bucket of known volume

IV. Cropping pattern

Sl. No.	Crops	Variety	Rainfed area (acres)	Output in quintals	Area irrigated by well/s(acres)	Output in quintals	
i.	Kharif						
1							
2							
3							
4							
ii.	Rabi						
1							
2							
3							
4							
iii.	Summer						
1							
2							
3							
4							
5							
6							
	Perennial crops						Annual cost for perennial crops
1							
2							
3							
4							
5							

V. Cost of cultivation: sunflower
Variety/hybrid:

Intercrop:

Area:

Source of irrigation any:

Date of sowing:

a. Labour requirement and charges

Particulars	Human labour				Bullock labour		Machine labour (hrs)	
	Man day	Rs	Woman day	Rs				
Seed treatment								
Land preparation								
FYM application								
Seed bed preparation								
Transplanting								
Fertilizer application								
a. basal dose								
b. top dressing								
Hand weeding								
Weedicide application								
Spraying								
Irrigation								
Harvesting								
Threshing and winnowing								
Packing, grading,								
Transport to the market								
Wage rate (Rs/day)								

VI. Material input cost

Sl. No	Particulars	Quantity	Value (in Rs)
1	Seed		
2	Fym		
3	Fertilizers		
4	ppc		
5	Any other		

VII. Yield and income

Crop	Main product		By product		Total returns
	Qty	Amt (Rs)	Qty (Rs)	Amt	

VIII. Recommended practices/technologies by AICRP/Dept. of Agriculture/any other agency and followed

Particular	Time of application	Qty/acre	No. of times	Remarks (reasons for non adoption)
Variety/Hybrid				
Plowing				
Harrowing				
Seed sowing/planting				
N				
P				
K				
Sulfur				
Zinc sulphate				
Bio fertilizer: rhizobium azospirillum				
Green manure				
FYM				
Soil type				
Soil testing				
Depth of sowing				
Spacing				
Contour bed/ridge and furrow				
Intercultivation				
Irrigation				
Intercropping				
Pheromone trap				
NSKE				
Pesticides :				
Insecticides:				
Weedicides :				
Boran				
Others if any				

IX. Technology adoption

Crop	Variety used earlier	Variety cultivated at present	Why did you shift to the present variety	Source of information	Subsidy received if any	Major change/s between this variety and previous variety	Yield of previous variety	Yield of present variety	Price per quintal received for previous variety	Cost of cultivation of previous variety
Sunflower										

X. Constraints

Particulars	No	Low	Medium	High	Remarks (why?)	Source of information/facility
Availability of seed of the new variety in right time						
Availability of fertilizers						
Availability of labour						
Availability of credit						
Incidence of pests and disease						
Lack of technical know how						
Unstable yields						
Price fluctuation						
Low output price						
Any others						

XI. Problems specific to the new variety

Crop	Variety	Problems reg cultivation	Problems regarding marketing	Problems relating to Technology	Your solutions

XII. Access to and availability of inputs, technical inputs, marketing facility etc

particulars	Source	Excess	Quick/sufficient	Moderate	Slow/insufficient
Inputs availability					
Technology availability					
Technical inputs availability					
Marketing facility					
Any marketing problem					

XIII. Different sources of income

Source	Amount (in Rs)
Agriculture (crops +perennials +Dairy)	
Sericulture	
Wages	
Trade	
Any others	